

INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

Scientific Journal

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EDITORIAL FOR THE THEMATIC ISSUE INNOVATION FOR BUSINESS PERFORMANCE: APPROACHES AND APPLICATIONS

This thematic issue of INDECS is focused on approaches and applications that foster the positive impact of innovation to business performance. The leverage for this special issue was an international conference. The 2nd International Conference ENTRENOVA '15 (Enterprise Research Innovation Conference) was organized in Kotor, Montenegro, on September 10-11, 2015. ENTRENOVA is a multi-disciplinary conference dedicated to examining, comprehending and meritoriously countering to the economic, management, organizational, marketing and other issues inquired by innovation, information technology, and R&D, driven by enterprises.

The articles were accepted after a blindly review process of two independent reviewers selected from the members of Program Committee of the symposium. At ENTRENOVA '15 it was agreed to publish thematic issue of INDECS including a selection of refereed journal version of papers presented at the symposium in Kotor, Montenegro.

The call for thematic issue of INDECS was open to participants of ENTRENOVA '15 as well as to other researchers and practitioners from the fields of management, innovation and management information systems. Six submissions for thematic issue of INDECS were received, some of them being extended journal version of short symposium papers from proceedings. Each submission was first reviewed by guest editors and then blind reviewed by two experts.

CONTRIBUTIONS

Because the purpose of thematic issue of INDECS is also to promote innovation and research in economy with an emphasis on the information technology (such as information systems, data mining, neuromarketing), the six articles accepted for this issue present a variety of methods, research and literature reviews on these topics.

Bilal Zorić (2015) used the neural networks data mining technique to predict customer churn in a small Croatian bank. Further actions for the bank in question were suggested according to the findings.

Ibrahimović and Bajgorić (2015) created a Bayesian Belief Network model for predicting the information system availability in BiH financial institutions to determine whether the factors that affect the availability of IS in BiH are the same as in USA and Western Europe. Monte-Carlo simulation was used for model validation.

Ćosić (2015) gave an overview of neuromarketing and neuromarketing techniques, together with their ethical implications. The application of neuromarketing in market research was shown in an eye tracking study of the commercial that was presented to 21 subjects.

Turulja and Bajgorić (2015) explore the relationship between IT capability (IT knowledge, IT operations and IT infrastructure), innovation (behavioural, product, process and market innovativeness) and firm performance in Bosnia and Herzegovina.

Shukarov and Marić (2015) explore the impact of institutions, education and innovation in economic growth by exploring the indicators from the World Bank Data Base in transition economies that are either following the horizontal industrial policy according to the EU accession requirements (Serbia and Macedonia) or have already met the requirements (Slovenia and Bulgaria).

Vig and Dumičić (2015) have conducted a survey of 100 Croatian medium and large size companies in order to investigate the relationship between commitment to business ethics and nonfinancial business performance. They estimate three multiple regression models w (client satisfaction, human resources management and innovativeness and efficiency of business processes) – that measure the nonfinancial business performance with 9 independent variables that measure commitment to business ethics.

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PREDICTING CUSTOMER CHURN IN BANKING INDUSTRY USING NEURAL NETWORKS

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ABSTRACT

The aim of this article is to present a case study of usage of one of the data mining methods, neural network, in knowledge discovery from databases in the banking industry. Data mining is automated process of analysing, organization or grouping a large set of data from different perspectives and summarizing it into useful information using special algorithms. Data mining can help to resolve banking problems by finding some regularity, causality and correlation to business information which are not visible at first sight because they are hidden in large amounts of data. In this paper, we used one of the data mining methods, neural network, within the software package Alyuda NeuroIntelligence to predict customer churn in bank. The focus on customer churn is to determinate the customers who are at risk of leaving and analysing whether those customers are worth retaining. Neural network is statistical learning model inspired by biological neural and it is used to estimate or approximate functions that can depend on a large number of inputs which are generally unknown. Although the method itself is complicated, there are tools that enable the use of neural networks without much prior knowledge of how they operate. The results show that clients who use more bank services (products) are more loyal, so bank should focus on those clients who use less than three products, and offer them products according to their needs. Similar results are obtained for different network topologies.

KEY WORDS

data mining, neural network, banking, customer churn

CLASSIFICATION

JEL: C45, G21

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INTRODUCTION

With increased availability of data, inexpensive storage and processing power, the amount of raw data stored in banking databases is huge and constantly increasing. However, raw data by itself does not provide much information. Data mining is used to discover patterns and relationships in data in order to improve business decision processes. Its tools can answer business questions that in the past were too time consuming to resolve. We can define it as an interdisciplinary field that brings together techniques from machine learning, pattern recognition, statistics, database systems, data visualization, information theory, knowledge acquisition, artificial intelligence and neural networks [1]. Specific uses of data mining include: Market segmentation, Customer churn, Fraud detection, Direct marketing, Interactive marketing, Market basket analysis, Trend analysis, Credit analysis, Predicting payment default, etc [2].

In this paper, we will focus on Customer churn. Techniques that are most commonly used to predict customer churn are: neural networks, support vector machines and logistic regression models [3]. We want to make a model from stored customer data to predict churn and to prevent the customer's turnover. Data mining research literature suggests that machine learning techniques, such as neural networks should be used for non-parametric datasets, because they often outperform traditional statistical techniques such as linear and quadratic discriminant analysis approaches [4].

In the era of globalization and intense competition in banking industry, banks are forced to fight more creatively and proactively to gain and maintain their clients. Questions data mining can answer are:

- What transactions does a customer do before shifting to a competitor bank?,
- Which bank products are often availed of together by which groups of customers?,
- What patterns in credit transactions show increased risk of fraud?,
- What is the profile of a high-risk borrower?, and
- What services and benefits would current customers likely desire [5]?

Banks have realized that customer relations are a very important factor for their success. The challenge banks face is how to retain most profitable customers. Literature suggests that a small change in the retention rate can result in significant impact on business [6]. Huge amount of customer and transaction data are maintained by banks, but because of size of these databases makes it impossible for the banks to analyze and to retrieve useful information for the decision makers. Data mining is a powerful tool that can find patterns and relationships within a data. Using data mining technique, it is possible to build a successful predictive model which transforms data into meaningful information [7].

This paper proposes a neural network based approach to predict customer churn in bank. Real-world data from one of the small Croatian banks was used for creating a model for Customer churn. The main hypothesis was that clients who use more bank services (products) are more loyal, and bank should focus on those clients who use less than three products, and offer them products according to their needs.

METHODOLOGY

DATA MINING PROCESS

The Data Mining Process is an iterative process which does not stop when a particular solution is deployed. There are four main phases in every data mining project.

First, there is initial phase of Problem definition in which specific business problem is translated into data mining problem.

Second phase is Data gathering and preparation phase. In this phase we transform data into prespecified format and we perform data cleansing, which is the process of detecting and correcting, or removing corrupt, inaccurate or irrelevant records. Data preparation tasks are likely to be performed multiple times, and not in any prescribed order. This phase can take up to 80 % of all analysis time. Data quality is a major challenge in data mining [8].

Then, there is Model building and evaluation phase. In this phase, various modelling techniques are selected and applied and parameters are calibrated to optimal values.

Four phase is Knowledge deployment, use of data mining within a target environment. In this phase we organize and present the results of data mining to the user [9]. The discovered knowledge is visually presented. Visualization techniques are more effective in understanding the output for end users [10].

DATA ANALYSIS

The used database consist information on 1866 clients on the date of analysis. We wanted to show that there is much smaller possibility for client that uses two or more bank products to leave the bank, in comparison to clients with just one product. Based on the information that we got from the bank, we determined each client's likelihood to leave the bank, whether it is low or high. We designed neural network using Alyuda NeuroIntelligence software package and we got a model in which we can determine likelihood of client leaving the bank on the basis of some data. Characteristics that we used are: sex, age, private status, average monthly income, usage of internet banking and usage of two or more bank products.

Bank products are currency account, credit, savings, internet banking, mobile banking, SMS, standing orders, etc. We grouped similar products together, so we have only one category Savings and not special savings like Open, Active, Currency, Foreign Currency, etc. We did the same thing with Credits. We did this because the bank has many different products and few customers using these products. We divided Private status into: employed, pensioners, students and unemployed. Average monthly income we divided into these categories: 0 to 5 000,00 kn, from 5 000,00 kn to 10 000,00 kn, from 10 000,00 kn to 20 000,00 kn and more than 20 000,00 kn. By age, we divided them from 0 to 25, from 26 to 35, from 36 to 50, from 51 to 60, and more than 61. We used one client as the basic unit. We achieved the uniqueness of the client by choosing them by registration number.

As we mentioned earlier, data preparation is the most time consuming phase. Problems that we had with data are: missing values (financial laws are changing constantly, so some data that did not exist in the past has now become obligatory). Sometimes we could add these data on the basis of other data (sex, by name and surname), sometimes we could not do that out of several reasons: we needed to contact the client in order to get the answer (average monthly income, place of birth), sometimes large amount of data was missing or it was incomplete, sometimes there was a big number of possible input data, nonlinear dependences, inconsistency (different names for the same attribute), contain errors or exceptions.

DESCRIPTION AND APPLICATION OF THE CHOSEN METHOD

Neural networks are considered alternative statistical methods. Today, there are tools that enable analysts to use neural networks without the knowledge of how they operate [11]. A neural network is a system of programs and data structures that imitates the operation of the human brain. It is nonlinear predictive model that learns through training and resembles

biological neural networks in structure [12]. The basic building block of a neural network is the neuron. Each neuron consists of two parts: the net function and the activation function. The net function determines how the network inputs are combined inside neuron. There are three types of neurons: input, hidden and output. The output of the neuron is related to the network input via linear or non-linear transformations called activation function [13]. The result of output neuron is called prediction. The difference between a classical approach and neural networks is that in the classical approach first a mathematical model of the measured data is developed and then a system based on the measured model is developed. Neural networks operate directly with the data and do not need to know the model of the measured data. The process works by analysing past events and making current decisions based upon past experience, it learns from examples. Neural networks are typically organized in layers. Layers are made up of a number of interconnected nodes which contain an activation function. Patterns are presented to the network via the input layer, which communicates to one or more hidden layers where the actual processing is done via a system of weighted connections. The hidden layers then link to an output layer where the answer is output. Each input is sent to every neuron in the hidden layer and then each hidden layer's neuron's output is connected to every neuron in the next layer.

Neural networks work very well for problems like capturing associations or discovering regularities within a set of patterns, problems where the volume, number of variables or diversity of the data is very big, problems where the relationships between variables are vaguely understood or the relationships are difficult to describe adequately with conventional approaches [14]. Today, neural networks are applied in many areas of life due to its ability to capture complex patterns present in the data, such as medicine, banking, engineering, geology, physics, etc., usually for the following tasks: pattern recognition, image processing, speech processing, optimization problems, nonlinear control, processing inaccurate and incomplete data, simulation etc. Usually, it is combined with other methods because of the difficult interpretation of the results [15].

One of the disadvantages of neural networks is relatively slow and tedious process of learning model. Another disadvantage is that neural networks do not offer as final data model understandable relationship between important variables. The model is implicit, relationships between variables are hidden in the network structure [16].

RESULTS

The paper used neural network method within the software package Alyuda NeuroIntelligence to detect Customer churn. After selecting the database, software goes through all the above mentioned phases.

In data analysis phase, we are defining three types of characteristics: characteristics which we will reject (name, surname), characteristics we will use, and determine the target characteristics that we want to calculate. Alyuda NeuroIntelligence divides Data into three sets: training, validation and testing set.

In preprocessing phase program adds some columns if data is marked as Categorical.

In the network design phase we are selecting a number of hidden layers. Program offers the best topology, which we can change. In our case, that is a neural network with three hidden layers with 8, 4 and 2 neurons.

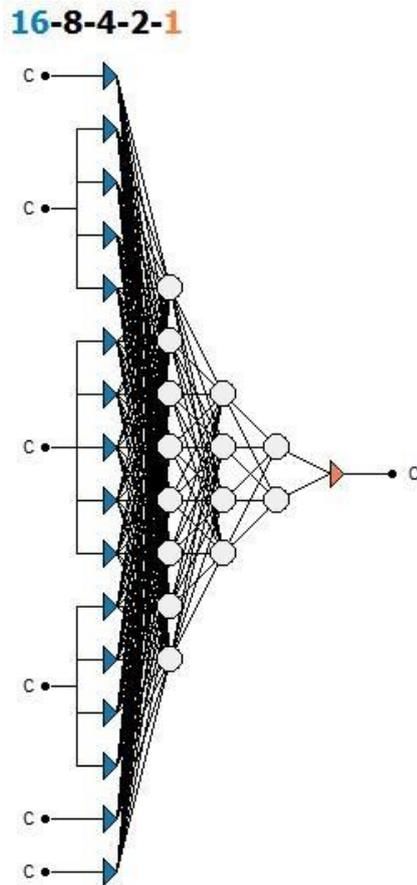


Figure 1. Alyuda – Network Topology.

After designing, there is training in which we can define different parameters as shown in Figure 2.

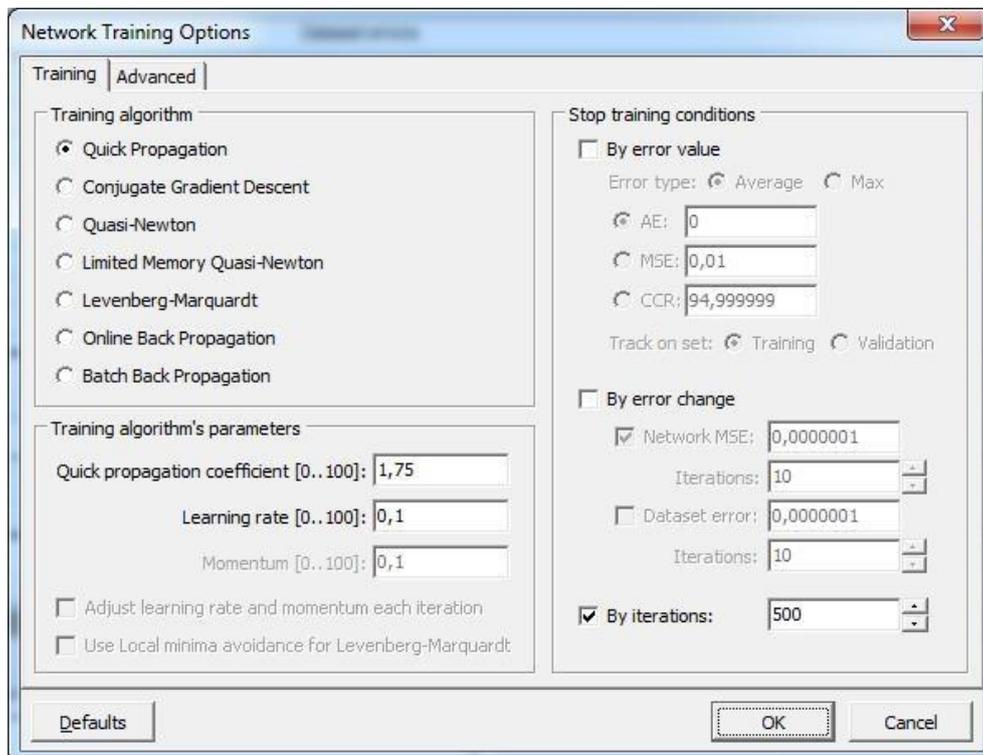


Figure 2. Alyuda – Network Training Options.

After training the network, we get results as shown in Figure 3.

| Parameters | | |
|---------------------------|---------------------|------------|
| | Training | Validation |
| CCR, %: | 95,984252 | 93,959732 |
| Network error: | 0,123164 | 0 |
| Error improvement: | 0,000009 | |
| Iteration: | 501 | |
| Training speed, iter/sec: | 62,625026 | |
| Architecture: | [16-8-4-2-1] | |
| Training algorithm: | Quick Propagation | |
| Training stop reason: | All iterations done | |

Figure 3. Alyuda – Network Training Results.

At the end we got model in which we can check the likelihood of client leaving the bank by entering some parameters.

The screenshot shows the Alyuda NeuroIntelligence software interface. At the top, there is a menu bar with options: File, View, Data, Network, Query, Options, Help. Below the menu is a toolbar with icons for Analyze, Preprocess, and Design. The main window is titled 'Manual Query' and contains a table for inputting parameters. The parameters are: SEX (F), PRIVSTATUS (dropdown menu), AGE (4), MONTHINC (4), IB (0), and 2MORE (0). Below the input table, there is a 'Results Table' showing the output of the query. The results table has columns: SEX, PRIVSTATUS, AGE, MONTHINC, IB, 2MORE, and PROBOFLEAVING. The results are as follows:

| SEX | PRIVSTATUS | AGE | MONTHINC | IB | 2MORE | PROBOFLEAVING |
|-----|------------|-----|----------|----|-------|---------------|
| M | EMPLOYED | 2 | 3 | 0 | 1 | low |
| M | PENSIONER | 4 | 1 | 0 | 1 | low |
| M | UNEMPLOYED | 3 | 2 | 1 | 0 | low |
| F | STUDENT | 2 | 1 | 0 | 0 | high |
| M | STUDENT | 2 | 1 | 0 | 0 | high |
| M | EMPLOYED | 4 | 4 | 1 | 1 | low |

Figure 4. Alyuda – Query.

We can conclude that there is 'a problematic group' of young people (students) with less than three bank products, who in the future can become very important and very valuable clients. Bank should adjust its products to these clients. For example, Bank could introduce new products tailored to students' needs such as student loan, favourable interest rates, promotional use of internet banking, etc.

Also, we found out that by changing the topology of the neural network, we do not get better results. All topology we tried gave similar results.

DISCUSSION

The Bank has very well-tailored services for pensioners, and this is the reason of high proportion of pensioners in the total number of clients (691/1866), and their likelihood of going to the competition is extremely low. The Bank offers them various benefits from lower fees for managing current accounts, loans for pensioners, free standing orders, etc. Bank should do something similar with the other groups of clients. For example, it should enable students as much as possible on line services.

We have shown that a simple analysis and application of neural networks can reach important results for the bank. It would be possible to include additional characteristics such as credit return, unauthorized overdraft, monthly consumption, the amount of savings, etc. to get different models for different problems.

CONCLUSION

In order to be competitive in this market, banks have to be able to predict possible churners and take proactive actions to retain valuable loyal customers. Building an effective and accurate customer churn prediction model has become an important research problem for both academics and practitioners in recent years. Profiling enables a company to act in order to keep customers may leave (reducing churn or attrition), because it is usually far less expensive to keep a customer than to acquire a new one [17].

Neural network is a valuable forecast tool in financial economics due to the learning, generalization and nonlinear behaviour properties. It is powerful general-purpose software tool used for a number of data analysis tasks such as prediction, classification and clustering. Neural networks are used in finance such as portfolio management [18], credit rating [19] and predicting bankruptcy [20-22], forecasting exchange rates [23, 24], predicting stock values [25, 26], inflation [27] and cash forecasting [28] and others in order to achieve a reliable decision-making process through scientific approaches [29]. The ability of neural networks to discover nonlinear relationships in input data makes them ideal for modelling nonlinear dynamic systems such as banking industry.

The bank must operate on a long term customer strategy, young customers are recognized as being unprofitable in the early stage in lifecycle but will become profitable later on. In this paper we have shown that more and more young people use internet banking and that bank should offer different products/services which could be arranged without the client coming to the bank, such as savings that can be arranged and used only on the internet. It is necessary to develop new products that could be offered to such customers in order to keep them.

Cross-selling is one of the most important ways to increase the profitability of existing customers while increasing their loyalty. By selling additional products to customers we associate with them, thus increasing their loyalty (we have seen that more loyal customers are those who use more than two bank products). Analysing the data available we can determine what the next best offer for a particular client is. For example, bank could offer car insurance together with the car loan.

In this article a customer churn analysis on database of small Croatian bank was presented. The analysis focused on churn prediction based on only one method, Neural network. We could access other important information that could help banks to get competitive advantage by using other methods such as segmentation, decision trees, self-organizing maps. We wanted to show the simple usage of a complex method and to encourage others in similar research. Today, there are many very good software packages for data mining that do not require much pre-knowledge to use, and results can be very useful.

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MODELING INFORMATION SYSTEM AVAILABILITY BY USING BAYESIAN BELIEF NETWORK APPROACH

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ABSTRACT

Modern information systems are expected to be always-on by providing services to end-users, regardless of time and location. This is particularly important for organizations and industries where information systems support real-time operations and mission-critical applications that need to be available on $24 \times 7 \times 365$ basis. Examples of such entities include process industries, telecommunications, healthcare, energy, banking, electronic commerce and a variety of cloud services. This article presents a modified Bayesian Belief Network model for predicting information system availability, introduced initially by Franke, U. and Johnson, P. (in article “Availability of enterprise IT systems – an expert-based Bayesian model”. *Software Quality Journal* 20(2), 369-394, 2012) based on a thorough review of several dimensions of the information system availability, we proposed a modified set of determinants. The model is parameterized by using probability elicitation process with the participation of experts from the financial sector of Bosnia and Herzegovina. The model validation was performed using Monte-Carlo simulation.

KEY WORDS

information systems, business continuity, availability, Bayesian belief network, Monte-Carlo simulation

CLASSIFICATION

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INTRODUCTION

In today's world, most of the business activities are associated with the use of information technology (IT). Information technologies enable and facilitate business, while, at the same time, a success of an organization is becoming increasingly dependent on the proper use of information technologies and managing risks associated with this dependency. The availability of information system (IS) is an essential requirement that business presents to IT departments. Forrester pointed out that across all industries, there is less and less tolerance for any kind of downtime [1]. According to Aberdeen Report, the average cost of an hour of downtime for large companies is 686 250 US\$, 215 638 US\$ for medium companies and 8 581 US\$ for small companies [2]. Gartner noted that 5 600 US\$ per minute is an average cost of downtime [3]. Butler reported that a 49 minutes failure of Amazon's services on 31st January 2013, resulted close to 5 million US\$ in missed revenue [4].

According to ITIL, availability is the characteristic of the IS to perform its agreed action at the request of an authorized user [5]. Availability in the broader sense implies that the information system is ready to serve end users, even in the event of unforeseen and catastrophic events. At the same time, IS has to be protected from various security threats.

In this study, an information system is defined in a broader sense, as a combination of interrelated components that, through their interactions, deliver the desired output. That means, information system, besides hardware and software, includes people, processes, culture and environment, which are all crucial for understanding, explaining and modeling availability and risk [6]. From the availability perspective, in this study, the system was regarded as a set of services that are available to end users. The total availability of the IS is the result of summarizing the availability of individual services that are components of the system. It is assumed that each service has an agreed-upon operation time (if service is to be continuously available 24×7 or only 8×5). The percentage of users affected by the outage of individual systems is also considered.

This article contains a thorough review of the literature in the IS availability field, addressing the problem from various perspectives. The primary goal of this research is to determine a set of factors that have the greatest influence on IS availability in BiH financial institutions. The second aim of the research is to compare the results of model parameterization with the results of Franke and Johnson [7]. As IS availability depends on local factors, especially of telecommunication and power network, climate and seismic factors, this study aims to determine whether the factors that affect the availability of IS in Bosnia and Herzegovina are the same as for the US and Western Europe and whether they have equal 'weights'.

AVAILABILITY OF INFORMATION SYSTEMS

IEEE defined the IS availability as "The degree to which a system or component is operational and accessible when required for use. Often expressed as a probability." [8]. Rauscher defines availability as a measure of the readiness of the system to be used for the purpose for which it was designed, when needed [9]. ISO 27 000 series of standards tied availability to the concept of organizational assets. The asset is available if it is accessible and ready for use at the request of an authorized person. In the context of this standard, the assets include information system components, facilities, networks and computers [10]. Singh gave a more quantitative definition: "Ps-system availability of the observed system S, is the probability that a system is operational and ready to provide services. As the Ps number should be close to 100 % as possible. The usual way to represent the IS availability is

counting nines. So 99,999 % availability is called five nines.” [11]. Availability is also defined as a combination of three concepts: reliability, accessibility and timeliness [12].

Most commonly, IS availability is referred to be part of the CIA (confidentiality, integrity, availability) information security triangle [13-20]. Also, in literature one can find term 'resilience' of an IS, where this term implies that the system “must remain available and maintain an acceptable level of performance when faced with various types of errors affecting the normal operation” [21] which is very close to the original definition of availability. Bajgorić used this term as a synonym for business continuity [22]. Gaddum discussed the resilience as IT, organizational and business issue, and introduced a model with six layers of resistance: strategy, organization, processes, data and applications, technologies and facilities [23]. Schiesser observed availability as optimization process of the productions systems readiness for accurately measuring, analyzing and reducing the system downtime [24].

Availability is expressed (measured) as the ratio of the time in which the system was available in relation to the total time. The basic formula for the IS availability calculation is

$$\text{Availability} = \frac{\text{System uptime}}{\text{System uptime} + \text{System downtime}} \quad (1)$$

For a complex system, we can get uptime time as the sum of uptime times for all subsystems. For example, if we have a system that provides the following services with the agreed times of availability: core banking 24 · 7, SWIFT 8 · 5, e-banking 24 · 7, m-banking 24 · 7, then a contractual system uptime annually $52 \cdot (24 \cdot 7 + 8 \cdot 5 + 24 \cdot 7 + 24 \cdot 7) = 28\,288$ hours. System downtime is collected for each service so that it takes into account the percentage of affected users. For example, the unavailability of a core banking service, affecting 5 % of users, for 20 minutes is equivalent to 1 minute of total unavailability of the core system.

Martin identified six major determinants of IS availability: physical security, audit and evaluation of the system efficiency, security policy, system monitoring and control of operations, business continuity management and backup management [25]. Franke and Johnson in their model [7] used 16 determinants that affect the availability of the system based on the 'Index of availability', introduced by Marcus et al. [26]. Bajgorić identified eight kinds of threats to the IT infrastructure that affect business continuity [22]. Rauscher et al. proposed a model for the reliability of communications infrastructure and identified the following components that affect reliability: the human factor, policies, hardware, software, network, load, environment, and power. In 2001, EMC conducted an extensive study on 250 European companies from different industries and various sizes, to identify causes of system disruptions. The study found that main reasons for disruption are: failures in hardware, interruptions in electric power supply, software errors, downtime of reserve power supply, data errors, errors of external service network), operating system, physical environment and disasters, 40 % were application errors, and 40 % were due to human mistakes [28].

There are different recommendations to raise the IS availability: Liu et al. [29], Raderius et al. [30], Franke and Johnson [31] suggested improvement of IS architecture, Martin recommended improving security policies [13], Gay suggested virtualization [32], Calzolari recommended clustering and virtualization [33] and Bajgorić et al. the application of standards in the IS governance [34]. Chen et al. suggested a strategy of diversification as a possible solution for reducing the IS unavailability, caused by attacks on network resources [19]. Bell proposed the use of the best practices in designing a data center to improve the IS availability [35]. In a study conducted in 2009, IBM recommended the following technologies and processes, to achieve high availability of the system: application management, availability management, capacity management, change management,

measurement management, network management, performance management, service management level and service recovery management [36].

INFORMATION SYSTEMS AVAILABILITY MODELING

Raderius et al. [30] cited block diagrams reliability and Monte-Carlo simulations as the most frequently used reliability modeling tool. They identified an inability to express uncertainty and high model dependency of the modeled system architecture as major problems of these methods. Malek et al. classified availability modeling methodologies into analytical, quantitative and qualitative [37]. Quantitative models are based on measurements and most often used to model availability of hardware components of IS. Research based on qualitative models are conducted less formally, and as primary modeling tools utilize questionnaires and interviews. As a result, they assign availability class to the IS. Trivadi et al. [38] distinguish qualitative and quantitative availability models. They defined qualitative models as models based on verbal descriptions and checklists and quantitative models as stochastic models based on hardware and software structure of the IS. Unlike most IS availability models, which represent availability as binary variable (system available or not available), Tokuno et al. [39] modeled availability of software-intensive systems in a way that recognize declines in the system performance as a condition that affects the availability. As a modeling tool, they used the Markov process. Goyal et al. also used Markov chains as IS availability modeling tool and made a high-level model of failure and recovery of IS components [40]. Immonen et al. defined the framework for the comparison of methods for reliability and availability modeling from the software architecture perspective [41]. Milanovic quoted the following analytical methods for availability modeling: Reliability Block Diagrams, Fault Trees, Reliability Graphs and Complex Configurations, Markov Models, Stochastic Petri Nets, Stochastic Activity Networks and Markov Reward Models, whereas, for qualitative models, he noted CMMI, ITIL, ISO/IEC 15 504-SPICE, CobiT, MOF, MITO, ISO/IEC 27 002 and ISO 12 207/IEEE 12 207 [42]. A method for availability analysis based on Fault Tree Analysis is presented by Narman et al [43]. Torabi, Soufi, and Sahebjamnia proposed a framework for conducting the business impact analysis by using MADM techniques [44].

METHODOLOGY

BAYESIAN NETWORKS

In this research, we used Bayesian Belief Networks (BBN) as a tool for analyzing the factors influencing the IS availability. Neil et al. wrote about the application of BBN to the modeling the operational risk of IT in financial institutions [45]. As the main advantages of BBN they noted enabling a combination of statistical and qualitative data and mapping the causal structure of the process, thus making it easier to understand and communicate with business users. Using BBN one can:

- a) combine proactive indicators of losses with a reactive results of measurements,
- b) take into account experts judgments,
- c) work with incomplete data and still get a reasonable prediction,
- d) implement a robust scenario analysis,
- e) test the robustness of the results,
- f) have a tool for visual reasoning and help in documenting,
- g) carry out a comparative analysis of alternative scenarios and robustness testing,
- h) assess changes in design of the IT infrastructure.

BBN are graphic models that combine graph theory and probability theory. Each BBN has two elements: a directed acyclic graph (DAG), which represents the structure, and a set of conditional probability tables (CPT). The nodes in the structure correspond to the observed variables, and the edges are formally interpreted as 'probabilistic independence'. CPT quantifies the relationship between the variable and its 'parent' in the graph [46]. Bayes' theorem is used for inference propagation so that the probability distribution can be quantified for each node if given the likelihood of an initial node and CPT for all nodes. For two events Bayes' theorem states:

$$P(A | B) = P(B|A) P(A) / P(B) \quad (2)$$

An interpretation of formula (2) is as follows: it is possible to calculate the conditional probability of event A, given the event B, using the conditional probability of event B, for a given event A and the probability of event B and the probability of event A. Although Bayesian networks significantly reduce the number of parameters, which needs to be determined by specifying the joint probability distribution, the number of parameters in the model remains one of the major bottlenecks of this framework. One way to reduce this number is to assume a functional relationship that defines the interaction between all the parents of a node. The most widely accepted and applied solution for this problem is the Noisy-OR model [47]. Noisy-OR model gives a causal interpretation to the interaction between the parent node and child node. It assumes that all causes (parents) are independent of each other regarding their ability to influence the variable effect (the child). Given these assumptions Noisy-OR model provides a logarithmic reduction in the number of parameters required for the construction of the CPT, which effectively makes the building of large models for real life problems feasible. Noisy-OR model assumes the presence of any of the causes X_i is sufficient to obtain the presence of Y as the effect. The second assumption of Noisy-OR model is the ability of cause X_i to produce an effect is independent of the presence of other causes. However, the presence of the cause X_i in Noisy-OR model does not guarantee that effect Y will happen. In practical models, a situation where the absence of all modeled causes ensures the lack of impact almost never happens. To solve that weakness of Noisy-OR model, Henrion introduced the concept of a leakage or background probabilities that allows modeling the impact of a combination of factors that are not included in the model [48].

BBN have been widely applied in OpRisk, INFOSEC and availability modeling. Raderius et al. presented a case study where the availability of the information system was estimated using the 'extended influence diagrams' combined with an architectural metamodel [30]. Hinz et al. presented BBN model for assessing the risk of IT infrastructure. The parameters of this model were obtained using interviews with experts [49]. Weber et al. used the influence diagrams for the economic analysis of the IS availability [50]. Neil et al. presented the methodology for developing BBN model representing the operational risk of IT infrastructure in the financial institutions [45]. Wei et al. developed an integrated process, based on BBN, for efficient IT services management [51]. Sommestad et al. made a model based on the extended influence diagram, which enables the analysis of the cyber security of different architectural solutions [52]. Cemerlic et al. proposed a system for intrusion detection system (IDS) based on BBN [53]. Simonsson et al. proposed a model for measuring IT governance efficiency based on BBN [54]. Lande et al. modeled the critical information systems, using BBN [55]. Zhang et al. presented an innovative model to improve the availability of the system based on the BBN in which the data for the CPT were obtained from the system logs [56]. Bonafede did a review of statistical methods that can be used to model business continuity and gave an example of BBN use for that purpose [57]. Different models, based on BBN, were made in the area of software reliability [58-60], and management of software development projects [61-63].

Franke and Johnson presented the model for decision support in the area of IS availability based on Leaky Noisy-OR BBN [7]. The model parameters were obtained based on the probability elicitation of 50 experts in the IS availability field. That model, with modifications based on the theoretical part of the study, has been applied in this research. Also, we propose a model that consists of thirteen variables representing thirteen domains affecting information systems availability. Those variables are: the physical environment, availability requirements management, operations management, change management, backup management, storage redundancy, avoiding errors in internal applications, avoiding errors in external services, network management, equipment and location of the DR data centre, resistant client/server systems, monitoring of relevant components, human resources management. If the best practices are implemented in one more of those domains, IS unavailability would be reduced.

The probability elicitation used for determining the model parameters was done by interviewing 23 experts dealing with IT systems availability in the financial sector in BiH. The research focused on information systems in the banking industry which, due to the presence of international and local regulations and regular audit reviews, have the necessary maturity level of IS governance to be suitable for modeling. During the elicitation, most experts agreed that the selection of variables in the model is adequate and that the model is comprehensive. Elicitation was conducted through structured interviews. In the first part of meetings, experts were trained and calibrated, while in the second part experts filled in the questionnaire. The questionnaire consisted of three sets of questions. Experts were first asked to estimate the impact of individual variables on system availability. In the second question, experts gave their assessment of the situation in the areas described by the variables in the financial sector in BiH. To answer the third question, they estimated the necessary investments to bring the field represented by the variable to the level of best practices.

As the system consists of several services provided to internal and external customers, overall system availability is defined as the average availability of each service weighted by a factor of importance of a service (for example different weight is given for a payment card authorization service and a service that calculates fixed assets depreciation). We used the equation bellow for the availability calculation.

$$A_i = \frac{\sum_i A_i k_i}{\sum_i k_i} \quad (3)$$

In formula (3) A represents overall system availability, A_i represents an availability of service s_i , and k_i represents a coefficient significance of service s_i .

When calculating the availability of a particular service one should take into account the service operating time, defined in the service level agreement, as well as the number of clients affected by the service interruption. The availability of a particular service is calculated according to the following formula:

$$A_i = \frac{t_i}{t_i + u t_i \frac{u n_i}{n_i}} \quad (4)$$

In formula (4) t_i is the total time that service s_i was available under service level agreement, $u t_i$ is the total time for which the system was unavailable, n_i is the total number of the service users, $u n_i$ is the number of service users where experienced service interruption during time $u t_i$.

According to the Leaky Noisy-OR model presented in Figure 1, the following formula applies to calculate the probability of IS availability.

$$P(A) = (1 - p_0) \prod_{i \in [1, n]} (1 - p_i) = (1 - p_0) \prod_{i \in [1, n]} (1 - k V_i (1 - B_i)) \quad (5)$$

In this formula n represents the number of variables in the model, V_i represents percentage of the improving system's availability if the best practices are applied, B_i represents a state of implementation of the best practices in different system's components, k represents transformation coefficient, p_0 represents a leak representing probability that the system is unavailable in the case that for all domains included in the model, best practices are applied.

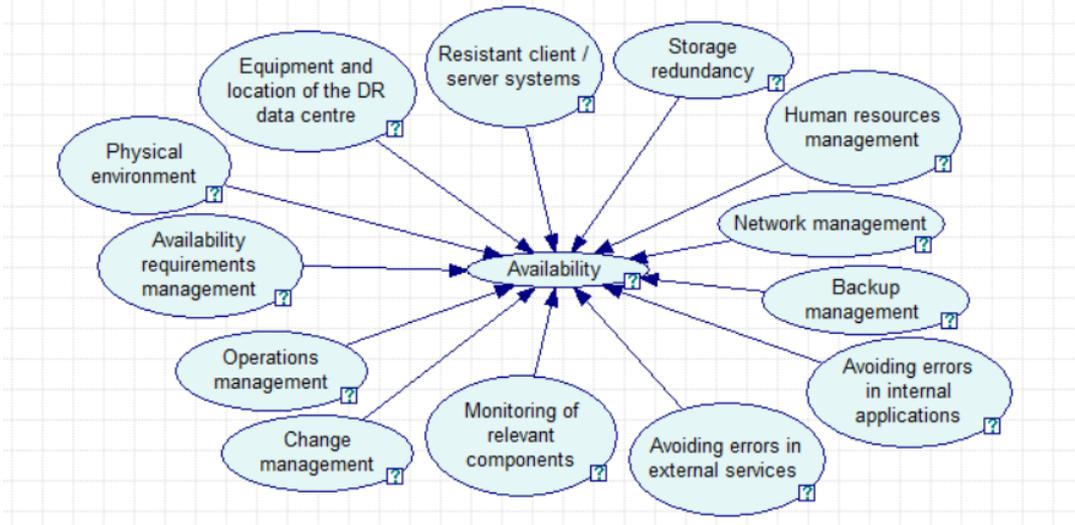


Figure 1. Leaky Noisy-OR BBN model.

RESULTS AND DISCUSSIONS

The research has shown that the ‘availability requirements management’ has the greatest impact on the availability (23,20 %), followed by ‘operations management’ (20,54 %) and the ‘equipment and location of the DR data center’ (19,52 %). The reduction of IS unavailability is the least impacted by ‘the physical environment’ (10,53 %), followed by ‘backup management’ (11,05 %) and ‘resistant client / server systems’ (11,81 %). The research results showed that the state of implementation of the best practices in the areas described by variables ranges from 4,60 to 6,85 on a scale from 1 to 10 depending on the area. The worst situation is in the fields of ‘monitoring of relevant components’ (4,6) and ‘availability requirements management’ (4,94). The best state in the IS of financial institutions in BiH is in the basic infrastructure areas: ‘backup management’ (6,85), ‘network management’ (6,54), ‘resistant client/server systems’ (6,39) and ‘the physical environment’ (6,05). According to the results of this research, the perception of experts is that the state of the essential IS infrastructure elements, including the server room, server and network infrastructure, data redundancy, backup management is much better than the process part, which includes change management, operations management, monitoring and requirements management. Assessment of the current maturity level of backup management may explain why the experts estimated that implementing the best practices in that area would have a small impact on reducing unavailability, as the situation in that field has been assessed as the best compared to all other areas that were part of the model. A similar explanation applies to the physical environment and server infrastructure. The above was the main reason to include assessed states of implementing best practices in the field as the prior probability for each parent node in BBN-based ‘Leaky Noisy-OR’ model. The conditional probability table for the node that represents availability is filled based on a linear transformation of the elicited impact values. The model is set up assuming the initial system

availability of 99 % and a leak of 0,01 %, which represents the unavailability of the system. Both of these parameters can be subsequently changed.

As part of the research, we compared the results with the study made by Franke and Johnson [7]. To be able to compare the results, it was necessary to transform the research results, since the different methods of calculating variables impact on the IS availability were used. Research findings and comparison are shown in Table 1. The first column represents the effects of each variable on the IS availability, where resulting percent is calculated as a mean of experts' opinions. The second column represents experts' opinions about the maturity level in the financial sector in BiH using scale 1-10. Third columns represent the research results, where as the resulting impact was calculated as the mode of experts' opinions modified with adjacent intervals. The fourth column represents Franke's results. Fourth, fifth and sixth columns represent ranking of data presented in first, third and fourth columns respectively.

Table 1. Elicitation results compared with Franke and Johnson [7].

| Variable | Percent median | Maturity level | Percent as mode | Percent Franke | PS | PP | PF |
|---|-----------------------|-----------------------|------------------------|-----------------------|-----------|-----------|-----------|
| Operations management | 20,54 | 4,94 | 8,85 | 23,00 | 2,00 | 4,00 | 4,00 |
| Network management | 19,53 | 5,24 | 6,99 | 12,95 | 3,00 | 7,00 | 6,00 |
| Equipment and location of the DR data center | 19,52 | 6,54 | 2,31 | 3,35 | 4,00 | 13,00 | 12,00 |
| Avoiding errors in internal applications | 17,58 | 5,28 | 6,44 | 16,86 | 5,00 | 10,00 | 5,00 |
| Avoiding errors in external services | 17,52 | 5,93 | 7,81 | 8,66 | 6,00 | 5,00 | 7,00 |
| Change management | 17,15 | 5,88 | 25,65 | 28,08 | 8,00 | 2,00 | 1,00 |
| Human resources management | 15,45 | 5,76 | 6,92 | - | 9,00 | 8,00 | - |
| Backup management | 11,05 | 5,56 | 7,65 | 5,27 | 12,00 | 6,00 | 10,00 |
| Availability requirements management | 23,20 | 5,44 | 29,64 | 25,25 | 1,00 | 1,00 | 3,00 |
| Storage redundancy | 17,20 | 4,60 | 5,00 | 5,34 | 7,00 | 11,00 | 9,00 |
| Resistant client/server systems | 11,81 | 6,39 | 3,94 | 3,65 | 11,00 | 12,00 | 11,00 |
| Physical environment | 10,54 | 6,85 | 10,00 | 8,22 | 13,00 | 3,00 | 8,00 |
| Monitoring | 12,33 | 6,05 | 6,71 | 26,14 | 10,00 | 9,00 | 2,00 |

Comparing data from with data from Franke and Johnson research we can notice that according to that research, there are more IS availability determinants with an impact greater than 20 %. In our study, only two variables have an impact greater than 20 % while the other variables impact IS availability with the 10 % and less. Among the four most significant areas,

both studies identified the same three areas: ‘availability requirements management’, ‘change management’ and ‘operations management’. Also, both studies have shown that least influential are variables ‘resistant client/server systems’ and ‘DR equipment and location’. The biggest differences are in the areas of ‘monitoring of relevant components’ and ‘avoiding errors in internal applications’. In research by Franke et al., they have a greater impact (2nd and 5th position) compared with our research (9th and 10th). Contrary, ‘physical environment’ has a significant impact according to our results (3th place) in comparison with Franke et al. research (8th place). When interpreting these outcomes, one should consider that we gathered data from the BiH banking sector while Franke et al. research did not have industry boundaries.

One of the disadvantages of the proposed model is a deterministic determination of parameters. In other words, each parameter in the network is set using the weighted mean values, obtained in the elicitation process, and not reflecting the diversity of experts’ opinion. For this reason, the same mathematical model was implemented using Microsoft Excel and Oracle Crystal Ball software. The base values of the input variables were set using values from CPT tables of the BBN model. However, each input variable was represented not only by the mean value but by also using the entire distribution obtained in the elicitation process. Figure 2 shows the distribution of impact of ‘availability requirements management’ variable on IS availability as an illustration how the distribution for each variable was modeled.



Figure 2. Input distribution.

In this way, we got the stochastic equivalent of the BBN model. We used this model to run Monte-Carlo simulations. The first simulation was run without optimization, just applying the distributions obtained by elicitation. Each simulation had a total of 10 000 trials. Resulting availability probability distribution and certainty intervals are shown in Figure 3 and Figure 4.

Diagrams in Figure 3 and Figure 4 show the stochastic nature of availability prediction. If there are 13 variables, which can affect the availability and which are not at the best practices level, it is not possible to precisely determine the time and the effect that this weakness may cause. Thus it is not possible accurately to predict the IS availability percent, rather it is possible to predict that availability will be inside the predicted range with particular certainty level. According to the results of the simulation, we got IS availability range from 98,33 % to 99,76 % with 90 % confidence for the case in which best practice are not applied. Mean and median values were 98,93 % and 98,97 % respectively, which was close to the initial assumption of 99 %.

CONCLUSION

The study presented an extensive literature review in the areas of availability and applications of BBN-based methods to decision-making in the fields of operational risk and IS. Based on the theoretical part of the research we adapted the model that was constructed by Franke et al. in two aspects. We changed input variables of the model, and incorporated information on the previous states of the variables, which improved the predictability of the model. Also, we

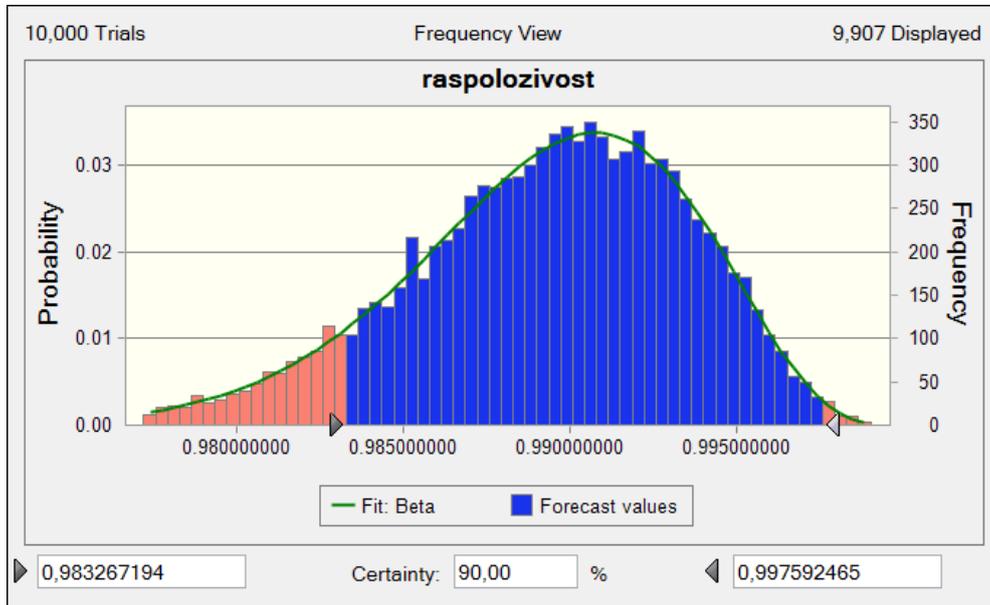


Figure 3. Availability distribution.

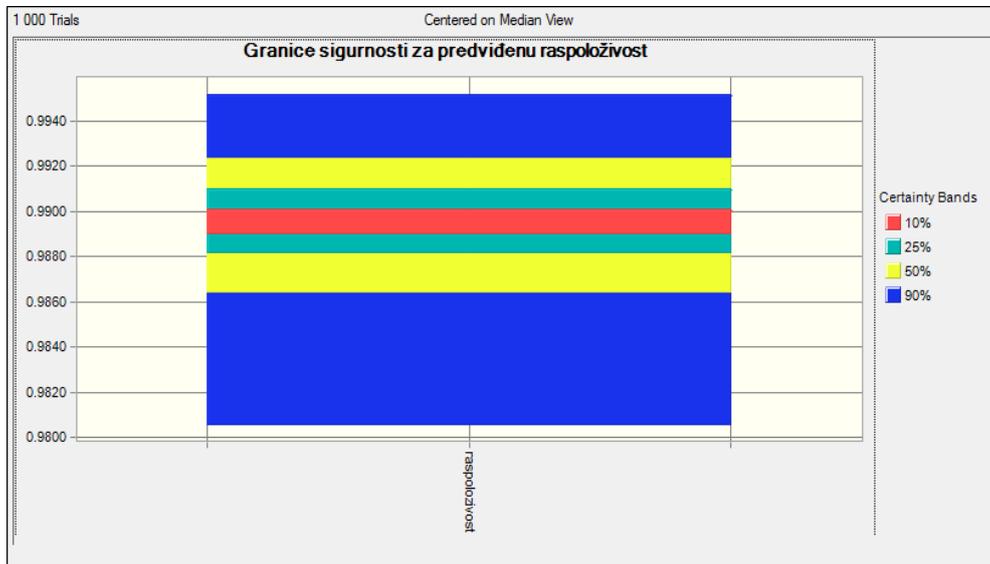


Figure 4. Availability certainty intervals.

conducted an extensive field research, providing the probability elicitation on the entire population of InfoSec, IS audit and IS management experts from the BiH banking sector. This research resulted in a picture of the state of implementation of best practices in the fields that affect the IS availability in BiH banking sector. We performed a comparative analysis of the research results, with results that are Franke and Johnson get in a study conducted in Western Europe. From a practical point of view, this work identified, taking into account local and regional specificities, which are the most influential factor for the IS availability of BiH banks.

LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

The fundamental assumption built into this model is the independence of the variables that enabled application of Leaky Noisy-OR approach. Another limitation is the binary representation of variables. Investment in a domain does not always results in bringing the domain to the level of best practice, but can improve the situation in the field, thus reducing the impact to the IS unavailability. Further study could lead to a model that would overcome this limitation by using continuous variables instead of using binary and Noisy-MAX node instead of Noisy-OR.

The empirical research was done on IS of banks in Bosnia and Herzegovina as the most mature in the field of availability management. In a situation where other industries are becoming increasingly dependent on IT and increase standards of IS governance, it would be interesting to conduct a similar survey of the general population, not limited to one industry. This would verify the applicability of the model to other industries and enable comparative cross-industry analysis.

Also, more empirical research based on real data of the IS unavailability incidents and their causes of would lead to empirical validation of the model.

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NEUROMARKETING IN MARKET RESEARCH

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ABSTRACT

Neuromarketing is a fairly new discipline that combines behavioural psychology, economics and consumer neuroscience. With the help of different techniques, such as functional magnetic resonance, electroencephalography, positron emission tomography, eye tracker etc., it measures respondent's reaction to different stimuli. It allows the researchers to gain insight into unconscious drivers of choice and preference which they would not be able to discover with traditional methods (focus groups, in depth interviews and questionnaires). In market research, most widely used neuromarketing technique is eye tracker. Me and my associates conducted a typical market research study of a TV commercial with a help of a stationary eye tracker and "Gazepoint" software. 21 respondents participated in the study. The study discovered that one scene in the commercial drew attention much more than the others. As neuromarketing raises ethical issues I reviewed the literature related to these issues and presented an overview of neuromarketing and neuromarketing techniques as well.

KEY WORDS

neuromarketing, eye tracking, market research, ethics

CLASSIFICATION

JEL: M3

INTRODUCTION

To those familiar with the latest development in marketing, the world may seem like the one from a Spielberg's *Minority Report*, where people's retinas are being scanned to predict their behaviour. It may seem like the commercials are going to talk to people approaching the marketing panel, combining data mining on their previous purchases. Facial recognition software is already used in some billboards that detect their viewers and adapt the content they display accordingly. One such billboard is the one for domestic violence where woman has been bruised less and less if more people are looking at her [1]. Some panels in Japan can identify gender, ethnicity and approximate age of the approaching shopper [2] and change the advertisement accordingly. One important culprit for this dystopian view of the marketing today is a fairly new marketing discipline called neuromarketing. Numerous studies question its ethics but a large number of studies see more benefits than disadvantages of neuromarketing.

WHAT IS NEUROMARKETING?

The term neuromarketing was first used in 2002 by a German professor Ale Smidts who defined neuromarketing as "the study of the cerebral mechanism to understand the consumer's behaviour in order to improve the marketing strategies" [3]. The discipline's founder is Gerry Zaltman from Harvard University who conducted a first FMRI study as a marketing tool way back in 1999 [4]. Today neuromarketing lies at the intersection of behavioural psychology, economics and consumer neuroscience. Consumer neuroscience studies cognitive and affective sides of human behaviour [5]. It uses a variety of brain scan techniques (such as FMRI, PET and EEG), eye tracking and physiological measurements (heart rate, breathing rate and galvanic skin reaction) to understand the unconscious drivers of choice and preference [5]. Because consumers are not aware of these drivers, they cannot be detected by traditional techniques such as focus groups, interviews and questionnaires. One can think that this brings the end to the traditional methods in market research, but it is more appropriate to view them as "upgraded" with methods such as eye tracking [5].

This unprecedented access to consumers' consciousness raises many ethical questions: from issues of invasive strategies (medical equipment usage for discovering what consumer is not aware of), to preference and choice manipulation (free will and discovery of the *buy buttons*) where marketing is trying to influence consumer decisions without consumers being aware of it, to exploitation of emotions to subliminal messages (consumers create emotional bonds with the brand as they are identifying with the marketing message). The fact that these techniques are used for profit-making, rather than scientific research, makes them even more ethically questionable [6].

In the remaining text I present a typical eye tracking study in a market research agency and show the benefits of this method. I also address the ethical issues of neuromarketing. But first I provide an overview of the techniques used in neuromarketing and how they are used by researchers to gain knowledge about consumer preferences that is not available by more traditional methods.

NEUROMARKETING TECHNIQUES

In all neuromarketing studies, participants are exposed to some sort of stimulus in form of different ads/commercials, still pictures, texts etc. and their response is observed/measured by one or more of the following techniques.

Functional magnetic resonance (FMRI) is an indirect measure of oxygen rich blood influx to an active part of the brain. It uses magnetic and radio waves to create brain images [4]. Among its many medical applications, FMRI can also be used to study people's preferences

and choices. By looking at brain scans it is possible to see which parts of the brain are active while receiving stimuli and/or making a decision. It is still very expensive and immobile, which means that it can be used only in a lab setting and an expert is needed to interpret results. This method also raises some ethical issues. First, if a medical condition (e.g. tumour) is found during a marketing study, should the subject be informed about it? Second, who owns the brain scans [6]? Also, strong magnetic field can have negative health effects and subjects should be informed about them.

Positron emission tomography (PET) scanner is a method where researchers inject radioactive ligands into the bloodstream of a subject and record how they accumulate in the brain. This method can be used to understand how substances that affect human behaviour (i.e. dopamine, glucose and serotonin) are distributed in the brain [5]. There are possible negative effects of radioactive material on subjects' health [6].

Electroencephalography (EEG) places electrodes on the outside of a skull and measures neurons' electrical activity. It is a second most popular neuromarketing method, partly thanks to its low price and small size, which makes it equally practical in lab and mobile settings. With the help of EEG we can measure things such as arousal ("how relevant a person finds something"), cognitive workload (how much information is being processed) and motivation [5]. EEG has the same ethical implication as fMRI in the domain of accidental discoveries [6].

Eye tracking method involves either eyeglasses (mobile) or a stationary tracker that uses infrared cameras to detect where a person is looking. They measure pupil dilation and some models can measure head movement. Pupil dilation can be caused by changes in brightness, emotional response and task difficulty. It can be used to predict things that grab our automatic attention (contrast, density, brightness, movement) [5]. Eye tracker is often combined with EEG. Eye tracking is the least intrusive technique and the only ethical issue is whether subjects know that they are participating in a marketing study and not in a scientific one.

In market research, eye tracking method can be used for various purposes such as product design tests, web pages and e-mail communications tests, marketing communication tests (commercials, listings, leaflets, sponsorships and product positioning). It is usually combined with quantitative (questionnaires) or qualitative (focus groups, in depth interviews) techniques.

When testing marketing communication, analysts ask questions such as: What did consumers notice and what they did not? Which part of the message draws the most attention? Do consumers see everything that the message designers want them to see? What is the best solution judging by the parameters listed above? Which place is the best for the advertisement? To address product placement and sponsorship testing, the following questions are usually asked: Are the sponsorships recognized and how much? How much is the product recognized?

If we are analysing a web page or an e-mail communication, the following questions are usually addressed: How readable is the content? Which parts are readable? What is being noticed? Is the message transferred? Which e-mails get opened more?

If the package design is being tested, the researchers want to know: Which elements of the design are noticed and looked at the most? How much time is needed to find relevant information¹?

WHAT DOES NEUROMARKETING EXPLORE?

The techniques used in neuromarketing can detect the focus of our attention and measure sensory experience. They can probe our memory and process of learning. Perhaps most importantly, they can tap into our emotions and motivation which arguably are the most important marketing target. In the rest of this section I give an overview of how the following processes in the neural system are measured: emotions, motivation, attention, senses and memory.

Emotions are instinctive responses that can be present before or without awareness. They shape our behaviour and the way we perceive the world. But how can we measure emotions? We can distinguish between arousal, the strength of an emotion (low to high), and valence, the direction of an emotion (positive vs. negative). We can make an emotion matrix that will rate these dimensions of emotions or we can track the subjects' respiration and pulse (arousal index), changes in activation in basal ganglia (part of the brain situated at the base of forebrain) and more specifically nucleus accumbens (reward centre and centre for negative emotions, a part of the basal ganglia) the insula (centre for both positive and negative emotions placed in cerebral cortex) and orbital frontal cortex (associated with people's enjoyment of food, music, faces, odours).

Participant's motivation (the reasons why people take actions, have desires and needs), consists of two systems: wanting and liking. Liking can be measured through what people say. For instance we can ask them to rate their liking of something with the grades from 1 to 5. On the other hand, wanting cannot be stated explicitly, but it can be measured through changes in work and effort, behavioural changes, changes in eye fixations and arousal. Changes in activation of basal ganglia and the nucleus accumbens show the activity of the wanting system while changes in activation of orbital frontal cortex show changes in liking.

An FMRI study by Martin Scot et al. [7] explored the liking system. It showed that when given contextual information, that is, when the subjects believed that the paintings they were looking at are from prestigious art galleries (meaning they are famous), as opposed to the ones taken from the internet (meaning they are unknown) was related to preference as they were rated much higher and a stronger activation of medial orbitofrontal cortex was seen (although none of the paintings shown were from prestigious galleries).

An FMRI study by Knutson et al. [8] finds that the stronger activation of nucleus accumbens (when looking at the product) predicts the choice: a stronger activation of this part of the brain indicates a higher likelihood of purchase; a stronger activation of the insula while looking at the price indicates a lower likelihood of purchase. This study also showed that all this happens several seconds before subjects have consciously made the choice.

Attention is another important process that selects a target of the mind's focus and suppresses all other stimuli, we can distinguish between bottom up (accidentally looking for something) and top-down (when looking for something particular) attention. What is important for bottom-up attention is that some things automatically grab our attention (movement, brightness, density, contrast) and just by changing the visual appearance of a product, people are more likely to look at it and also more likely to buy it [9]. Ramsøy et al. [10] use an experiment on the choice of paint brand (looking for a particular colour the subjects would like to paint their living room in) to study the top-down attention. They show how much we are unconsciously under the influence of advertisements while making a purchase decision. The subjects were shown a commercial for a particular brand of paint and then equipped with a mobile EEG and eye tracking glasses, and sent to a store. The authors report that 78 % of the control group, who did not see the commercial, bought a particular brand of paint, 91 % of the first target group, who saw a 50 second commercial, bought the paint, and 100 % of the second target group, who saw a 30 second commercial, bought it. Both target groups declared later that they were not under the influence of the commercial. Eye tracker also recorded that the target groups explored the shelves much more than the control group, while EEG measured their emotional and motivation responses. In another study, Ramsøy and Martin [11] discovered that subjective brand preference has a great impact on the likelihood that the brand will be consciously seen. The subjects were shown brand names very quickly and asked to rate their liking/disliking of the brand. The results indicate that the more a subject likes/dislikes a brand the more likely he or she is to recognize the brand. If a subject was indifferent or ignorant about the brand, it was more likely to go unnoticed by the subject.

Sensory neuromarketing deals with processing of senses (smell, sound, taste, sight and touch). Smell, for example, travels much faster to the brain, and this is related to the phenomenon of Proustian memory where a scent can bring up a lost childhood memory. That is why some stores use smells to increase the likelihood of buying the product. For example, added citrus scent that is sometimes used in produce department increases risk taking, which increases the likelihood of purchasing. Or the smell of leather in a shoe store gives the shoes added value as customers are convinced it is real leather. Ratneshwar and Morrin [12] examined the effects of ambient scents on recall and recognition of brands. They found that scent's congruence with the product has no effect on the time that consumers look at logos. The only thing that mattered was whether the scent was pleasant.

Finally, one of the most important processes in the brain is memory. There are different kinds of memory such as sensory, working memory (we measure cognitive load), intermediate and long term memory. Long term memory is then divided into declarative memory (episodic and semantic) and non-declarative memory. They all have different structures of the brain and neuromarketing tracks their activations. Simon McClure et al. [13] conducted an fMRI study on effects of memory on consumer preference by giving the participants a blind test of Pepsi and Coca-Cola. They found that the more the subjects enjoyed cola (it didn't matter which one of the two) they were tasting the stronger the activation of ventral medial prefrontal cortex (region for subjective pleasure experience). But if they were told that it is a Coca Cola, there was a stronger activation of hippocampus and the dorsolateral prefrontal cortex (memory structures). They did not get this when subjects were told they were drinking Pepsi although the two are hard to distinguish and Pepsi is also slightly sweeter. So this shows us that memory and the value of the brand has a significant effect on preference.

Other studies have shown that preference and knowledge are strongly correlated. The more people know about the brand the more they like it. Positive words and associations increase the liking as well, while the more people dislike something, the more negative things come to their minds [5].

METHODOLOGY

Two of my colleagues from Henda d.o.o. and I have designed a typical study of a TV commercial that shows how the eye tracking method is implemented in a market research agency. The commercial was downloaded from YouTube. It is 32 seconds long and it advertises 5 readymade soups from Podravka. The commercial consists of a dynamic and a static part. It presents three soups in the dynamic part and five soups (including the three already shown) in the static part. Only the static part is of the interest in this study. The static part of the commercial contains images of five different readymade soups along with five other elements: a slogan, a logo, a link to Podravka web page, a word „New“ and a tree.

The study was conducted with the help of a stationary eye tracker and the Gazepoint software in a market research agency (Henda d.o.o). We asked 21 subjects (15 women and 6 men; age 20 to 65) to volunteer in this study. The subjects were seated in front of a monitor on which the stationary eye tracker was mounted. After a short calibration, the commercial was shown to them, while the eye tracker was recording their eye movements. The results were exported to MS Excel and data was analysed. With the help of heat map, bee swarm and fog map we were able to visualise eye movements of the respondents both individually and as a group.

RESULTS

We uploaded the commercial into the eye tracking software (Gazepoint) and defined areas of interest. An area of interest is a result of an analyst's subjective assessment of what is interesting in a scene. An area is selected with the cursor and every fixation of a participant's

eye that falls in this area is recorded (repeated fixations as well). Eye tracker can measure eye movement in a matter of milli-seconds. Area of interest (AOI) is usually defined in consultation with the client but for the purpose of this paper we have defined ten of them. The material itself could have been a web site, a still picture or a simple text, depending on the aim of research. After the initial setup was completed, we asked the subjects to sit in front of the monitor and watch the commercial. During the exposure time, gaze movements are recorded. After all the subjects went through the same routine, we generated a heat map, a fog map (the inverse of heat map), bee swarms and fixation maps. Figure 1 shows the heat map of the static part of the commercial. The heat map uses a scale of colours to show where people were looking. “Warm colours” (e.g. red, yellow) indicate an area with a higher share of fixations, while “cold colours” (e.g. blue, green) indicate lower share of fixations. Most of the AOIs in our experiment are blue but there is a yellow and red spot on the AOI “Okruglica” soup. It should be noted that the “Okruglica” AOI is positioned in the middle of the picture, which is likely to affect the number of fixations. A more robust study would perform multiple measurements with different positions of AOIs.



Figure 1. Eye Tracking Heat Map of Podravka Commercial.

Numerical data is also available for detailed analysis in external statistical packages. These numbers include: AOI duration (in seconds), Number of viewers, Total viewers, Average time to first view (how much time has passed since the appearance of AOI till the fixation on this AOI occurred, in seconds), Average Time Viewed (what is the average viewing time in seconds), Average time viewed (%), Average number of fixations, Number of repeated fixations (respondents can come back and look at the AOI again) and Average number of revisits (how many times did the respondent looked at the AOI again). From there, we can calculate the share of viewers of that particular AOI; average time from the first appearance of the AOI till noticing the AOI and Average share of watching the AOI in total duration of the AOI. The table with the figures of interest are shown in Table 1.

At a first glance we can see that “Okruglica” has significantly better result than other AOIs and that the “Logo” hasn’t been seen by any of the subjects. A key indicator is the share of viewers of that particular AOI in total viewers. “Okruglica” has 62 % share of viewers, and “Tree” and “Slogan” follow with 48 %. It took the subjects much more time to spot “Tree” and “Slogan”, but they spent more time looking at the “Tree” and they were revisiting it. In this

Table 1. Key Indicators of the Eye Tracking Method.

| AOI | The share of viewers of that particular AOI in total viewers, % | Average time from the first appearance of the AOI till noticing the AOI | Average share of watching the AOI in total duration of the AOI, % | Average time viewed, s | Share of repeated fixations | Average number of revisits |
|------------------|---|---|---|------------------------|-----------------------------|----------------------------|
| <i>Okruglica</i> | 61,90 | 0,505 | 14,40 | 0,302 | 1 | 1 |
| <i>Tree</i> | 47,60 | 1,043 | 28,50 | 0,571 | 3 | 1 |
| <i>Slogan</i> | 47,60 | 0,694 | 13,80 | 0,277 | 2 | 1 |
| <i>Pričalica</i> | 42,90 | 0,524 | 21,70 | 0,455 | 1 | 1 |
| <i>Mljacketi</i> | 23,80 | 0,942 | 17,40 | 0,365 | 2 | 1 |
| <i>Smazolina</i> | 23,80 | 0,669 | 8,70 | 0,182 | 0 | 0 |
| <i>Zvezdica</i> | 14,30 | 0,726 | 10,40 | 0,219 | 1 | 1 |
| <i>Link</i> | 14,30 | 0,820 | 8,50 | 0,171 | 0 | 0 |
| <i>Novo</i> | 4,80 | 0,017 | 15,20 | 0,304 | 0 | 0 |
| <i>Logo</i> | 0,00 | 0,000 | 0,00 | 0,000 | 0 | 0 |

case we were interested only in share of viewers and average time from the first appearance of AOI till noticing the AOI because there was nothing specific we were looking for.

This data can be combined with demographic information (age, gender, number of children, working status, income, region and settlement size) about the participants, and further analysis can be performed.

DISCUSSION

Every consumer is affected by brands, social connections, context, price etc., either on a conscious or a subconscious level. Consumers are saturated by the commercials. It is estimated that the average consumer sees about 2 000 000 commercials in a life time [4] and the average American is offered about 3 000 commercials a day [14]. Some authors even joke that along with the id, ego and superego there is an ad-advertisement [14]. Ad is directly talking to the id that is constantly being evoked by so many choices-consumers have become childish and want to fulfil every desire that is triggered by any of the given influences. They do not remember most of the commercials consciously, so they run on autopilot when making purchase decisions most of the time, as they have more options and less time to decide. Modern advertisements have powerful influence on consumers, and marketing needs to keep up the pace with technology in order to help companies compete and keep them in business. Companies need to focus on keeping old customers and gaining new ones.

The objective of marketing today should be to know and understand customers so that the product can be personalized. It sometimes happens, though, that the results of the traditional methods are inadequate. They can be imprecise and inaccurate, so they need to be complemented with some of the neuromarketing techniques.

Some will argue that neuromarketing alters consumer’s brain and free will. But we do not know that much about the brain itself as to read people’s minds.

It might be spooky to use medical equipment for marketing purposes and that is why marketers need to inform consumers what kind of research it is, to make a clear cut between scientific and marketing research and to warn them of potential hazards. They should educate consumers

about developments in marketing so they do not feel invaded by neuromarketing techniques. Furthermore, there should be a legislative regulation of the advertisements and neuromarketing research in a sense that they can not mislead the customer. Such regulations do exist in European Union and USA for instance [6]. Neuromarketing can save millions of dollars spent on the wrong campaigns such as hazardous pictures on cigarette boxes that have no effect on smokers and smoking reduction [4]. It can be used in many other areas such as entertainment (multiple versions of a movie tailored for different audiences), food (more appealing food), architecture (easier orientation) and politics (brain responses to different people in politics) [4].

Eye tracking is the least invasive technique and therefore legitimate to use if the subjects are well informed of its purpose. It clearly gives an insight into where people are looking. Although they might be thinking about something else when looking at the image, they can be asked about their experience after the session with the help of traditional methods (in depth interviews). Alternatively, the potential client could create different versions of the commercial so the new research would be conducted and the results would be compared. In the case of Podravka commercial, one readymade soup popped out – “Okruglica”. This is probably one of the most popular soups in Croatia, made with grits dumplings that remind people of their family meals with homemade soups. Also the image is centred in the middle of a crowded picture and it is red, so it is not that surprising to see that 62 % of subjects viewed this particular image. As the density of details in the image is pretty high, some AOIs did not get noticed at all (e.g. the “Logo”) and some were noticed very little, (e.g. “Novo” AOI). These are important findings as the client can reduce the length of the commercial (as to save the costs of broadcast) or remove some less visible elements.

CONCLUSION

I have presented neuromarketing and its ethical implications through literature review and demonstrated the benefits of eye tracking method in a real world environment (market research agency). One of the limitations of this study is the small sample of respondents which is not representative of the population by age or gender. This is due to not setting the marketing goal of the study apart from showing a typical market research eye tracking study and how the eye tracker works. In other words, we did not know what was of interest to the potential client, so the population and therefore the representative sample were not set. The sample could consist of several groups of the respondents such as parents, working mothers, children etc. Also the colour and positioning of the images was fixed and this introduces a potential bias. It could be addressed in the future research by conducting the same experiment with multiple permutations of the products and their colours.

REMARK

¹<http://www.tobii.com/en>.

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INNOVATION AND INFORMATION TECHNOLOGY CAPABILITY AS ANTECEDENTS OF FIRMS' SUCCESS

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ABSTRACT

The primary aim of this article is to identify antecedents of firm's success in specific circumstances of the New economy. Many researchers have tried to answer the question "Why do some firms persistently outperform others?". One of the most dominant view on this issue is a resource based view (RBV) or resource-based theory (RBT). According to this theory, sources of competitive advantage begin with the notion that differences in performance are fundamentally due to the distinctive resources and capabilities that are valuable, rare, inimitable and non-substitutable. Information technology as a resource of the company has the increasing importance for the researches and managers. Research on the information technology (IT) value within organizations and firms' IT capabilities have expanded over the past decade. IT capability is defined as the existence of IT infrastructure, IT knowledge and IT operations within company. The purpose of this paper is to analyse the interaction impact of IT capability and firms' innovation on business performance. The study uses survey data from managers and structural equation modelling to assess the relationships between IT capability, firm's innovation and business performance. This study finds that both IT capability and innovation capability play important role in achieving greater business performance. The findings indicate that managers should focus on development of the IT function within company, taking into account importance of IT investment as well as IT knowledge, and promotion of innovativeness.

KEY WORDS

information technology capability, innovation, resource based view, business performance

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INTRODUCTION

Many scholars have tried to answer the question “Why do some firms persistently outperform others?” [1]. One of the approaches to answering this question began to dominate this discussion and it focused on what were known as a firm’s distinctive competencies and capabilities. “Distinctive competencies are those attributes of a firm that enable it to pursue a strategy more efficiently and effectively than other firms” [1]. This discussion led to the development of the several theories and approaches of which one of the most prominent is resource based theory [1-3]. Resource based theory (RBV) suggests that resources enable achievement of competitive advantage. Barney and Clark [4] have identified four characteristics of resources essential for gaining sustainable competitive advantage, namely, value, rarity, imperfect imitability, and organized to capture value, known as the VRIO framework. They classified firm resources into four categories: physical capital resources, financial capital resources, human capital resources and organizational capital resources.

In the age of globalization and intense competition, one of the most important resource is information technology (IT) used in a firm, which is a part of physical capital resources. Specifically, there are two main trends of the New economy: trend of globalization and exponential development of information technology [5]. Many scholars have new perspective of firms’ resources pointing out that in modern business, which is characterized by rapid and dynamic changes, the achievement of a successful business and competitive advantage is only possible if firms apply their abilities faster and more wisely than its competitors. In other words, firms’ resource base must be constantly improved and expanded in order to create the dynamic capabilities which are the basis for competitive advantage and a successful business of modern age. In order to answer the main question of this study, and taking care about the theoretical assumptions of the paper, we identified two basic resources typical for modern business: IT capability and innovativeness capability.

IT is a generic term that refers to programs, computers and telecommunications while IT capability is a broader term and refers to the use of these technologies in order to meet the information needs of the company [6, 7]. Also, globalization pressures and rapid technology advances increase the need for firms to continuously adapt, improve, and innovate. Firms with greater innovativeness will be more successful in responding to changing environments and developing new capacities to achieve better performance [8]. The purpose of this article is to analyse the impact of IT capability and firms’ innovation on business performance.

This article is structured as follows. First, we analyse the concepts of IT capability and innovation. We then propose and test hypotheses about the relations between IT capability, innovation and firm performance. Finally, we discuss our findings and implications as well as give suggestions for future research.

LITERATURE REVIEW

INNOVATION

Innovativeness is perceived as “exploring something new that has not existed before” [9]. Hurley and Hult [10] defined innovativeness as “the notion of openness to new ideas as aspects of a firm’s culture.” Innovative capability refers to the ability of a firm to develop new elements or a new combination of already known elements in products, processes, technologies, or management. As a result of innovativeness or innovative capabilities, firms generate different levels of innovations. Innovations can be classified in four categories: behavioural innovation, product innovation, process innovation, and market innovation [11]. According to [11] study, these innovation types are defining as follows:

- Behavioural innovativeness refers to the formation of an innovative culture, the overall internal receptivity to new ideas and innovation, demonstrated through individuals, teams and management enables,
- Product innovativeness refers to the novelty and meaningfulness of new products introduced at the market at a timely fashion”,
- Process innovativeness refers to the introduction of new production methods, new management approaches and new technology that can be used to improve production and management processes,
- Market innovativeness refers to the newness of approaches that companies adopt to enter and exploit the targeted market.

INFORMATION TECHNOLOGY CAPABILITY

Considering the growing importance of information in today’s business environment, achieving competence and capability with regard to the tools and processes used to manage information has taken on a new urgency. This capability is known as IT capability. Most of the papers, analysing IT capabilities, focus on IT infrastructure and IT skills necessary to exploit the potential of information technology [6]. Based on it, firms’ IT capability can be defined as the ability of firm to select, accept, configure and implement information technology. In other words, IT capability includes IT infrastructure within the company, as well as the supporting processes and knowledge related to it.

In this article, we use conceptualization of IT capability done by [12]. In the mentioned study, IT capability is seen as a construct or a concept made up of three dimensions:

- IT knowledge is a degree to which the organization understands the capabilities of existing and emerging IT, or how organization is aware of IT possibilities [12],
- IT operations stand for the extent to which the firm uses IT to improve its business effectiveness, or possession of the IT-related methods, processes and techniques,
- IT infrastructure includes hardware, software and support staff, or tools and resources that contribute to the acquisition, processing, storage, dissemination and use of information [12].

Taken together, these three dimensions of IT capability interact and impact the degree to which an organization can leverage its investments in IT for strategic gains [13].

FIRMS’ SUCCESS

Based on the literature review, it was found that the success of the company is measured with indicators of business performance [12, 14].

THEORETICAL MODEL AND HYPOTHESES

On the basis of the previous sections we propose two hypotheses about the relations between IT capability and innovativeness and innovativeness and firm performance.

IT CAPABILITY AND INNOVATIVENESS

During the past decade there has been a growing interest for the importance and value of information technology for the firms. Most of the scholars failed to confirm the direct impact of IT on business performance. Pérez-López and Alegre [12] state that the reason for this inconsistency probably lies in the failure of the authors to recognize various organizational capacities as important intermediaries between IT and performance.

Most IT researches are focused on the analysis of the factors influencing the adoption of IT [15, 16], where the analysed factors can be classified into three categories: factors related

to the firms' staff that will use IT, factors related to the firms' characteristics and factors related to the business environment in which the firm operates [17]. The impact of IT on firms' innovativeness is very little analysed, mainly as the impact of a particular technology to a particular category of innovation. In the study [17], it is analysed the impact of IT on innovation and competitiveness by demonstrating that only the use of various IT does not affect the level of competitiveness, nor affect the level of innovation of the firm. In a small number of researches it has investigated not only the use of IT, but the existence of relating level of IT skills and its impact on innovation. In line with previous studies that have shown that IT alone will not result in increased innovation and competitiveness, but improvement IT skills along with IT processes and IT infrastructure will have positive impact on innovativeness, we propose the following hypothesis:

H1: IT capability has a positive effect on the innovativeness.

INNOVATIVE CAPABILITY AND FIRM PERFORMANCE

“Innovation has become the industrial religion of the late 20th century. Business sees it as the key to increasing profits and market share” [18]. Innovations provide distinct advantages for the firm, helping it to achieve competitive advantages and superior business performance. Firms' ability to innovate is the most important determinant of the success [19]. Innovation is recognized as one of the key assumptions of competitive advantage and business performance of the company, especially in the modern economy [10]. On the basis of these statements, the proposed hypothesis is as follows:

H2: Innovativeness has a positive effect on the firm performance.

METHODOLOGY

The first step of research was to choose population and objects to analyse. Considering that the topic is relevant for all business activities and that research will be done on the case of Bosnia and Herzegovina, which is relatively small market, it is decided to cover companies from all industries and business sectors. The classification of sectors is taken from the statistical classification of economic activities of the European Community – NACE.

In order to collect the data and for the purpose of this study, a questionnaire was distributed to the firms' management as an online survey using LimeSurvey software using mailing lists. All questionnaires included a cover letter explaining the purpose of the study and assuring anonymity. Data was collected in the period of March-July of 2015.

A total of 531 questionnaires were completed and saved. Of these 531 questionnaires, 87 had a high percentage of missing values, so we decided to eliminate them, following the complete case approach described in [20]. Summarily, 444 questionnaires were left for the analysis. The selected sample has characteristics of a convenient because firms are selected for the sample with respect to their availability and firms of each economic activity are included.

MEASURES

All the variables were measured on seven-point Likert scales ranging from 1 – strongly disagree to 7 – strongly agree.

IT Capability

The measurement scale for IT capability (ITC) was created using some of the items from the scales proposed by [21] and [22]. To be precise, IT knowledge and IT infrastructure scales were taken from [21], while IT operations, due to the wording and easier translation were taken from [22]. ITC is second-order reflective measurement model with three first-order factors and 10 indicators.

Innovation

The measurement scale for innovation (Inno) was adapted from [11] and it consisted of four dimensions: behavioural innovation, product innovation, process innovation and market innovation. Innovativeness is second-order reflective measurement model with four first-order factors and 13 indicators.

Firms' Performance

This scale was adapted from [14, 23] and it consisted of 4 items measuring firm's performance (FP) related to profit, sales, return on investment and market share. This is first-order measurement model.

Conceptual model which will be tested in following section is presented in Figure 1. Because latent variables are unobserved and have no scales of their own, their origin and unit of measurement have defined by fixing first variable to unity [24].

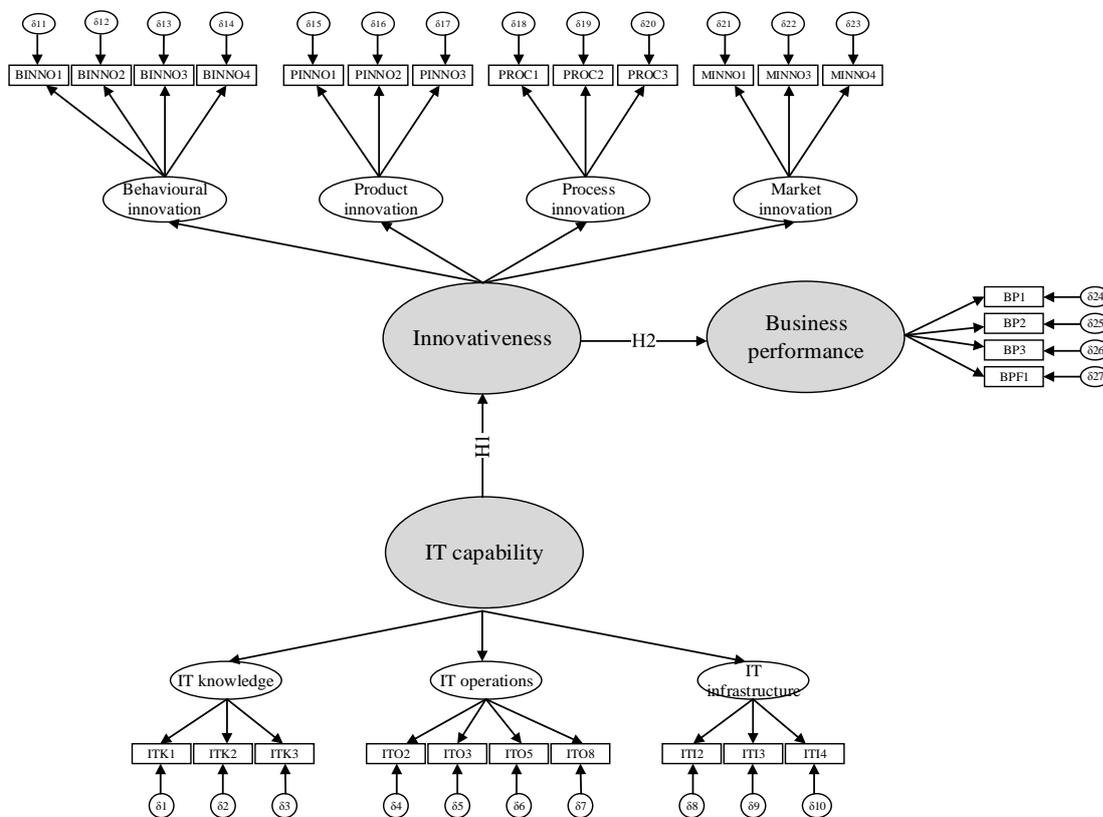


Figure 1. Conceptual Model.

The psychometric properties of the measurement scales were assessed by establishment of content validity and construct validity. Content validity was established through personal interviews with panel of experts: two academics and four managers, during the phase of questionnaire development.

The construct validity of the measures is tested employing confirmatory factor analysis (CFA) using Lisrel 8.8. Reliability is tested checking values of inter-item correlations and item-total correlations. Also, Cronbach's alpha for all three constructs are greater than 0,70.

Standardized factor loadings of all indicators are greater than 0,50 which is an indicator of the convergent validity [20]. This is also proven with average variance extracted (AVE) which is greater than 0,50 for all dimensions. Furthermore, all latent variables in both samples achieved an acceptable level of CR with all values above threshold above the 0,50. Also, the correlation coefficient for all latent constructs and the respective square root of AVE values are reported

in Table 1, showing that discriminant validity is achieved. There is a high correlation between product and market innovation which is already confirmed in earlier researches [10].

Table 2 shows goodness-of-fit indices for measurement models, and all of them are above/below cut-off value.

The CFA returns an acceptable level of fit-for-all of three measurement models reported in Table 2. RMSEA was less than 0,08, while SRMR was less than 0,05 and CFI and NFI were all greater than the 0,95 cut-off value [20].

Table 1. Results of Reliability and Validity Tests for Measurement Models.

| Dimensions | | CR | AVE | | | α | |
|------------|--------------------------------|-------|-------|--------------|--------------|--------------|--------------|
| ITC | IT Knowledge (ITK) | 0,867 | 0,685 | 0,828 | | 0,860 | |
| | IT Operations (ITO) | 0,869 | 0,624 | 0,788 | 0,790 | 0,867 | |
| | IT Infrastructure (ITI) | 0,794 | 0,566 | 0,714 | 0,778 | 0,752 | 0,775 |
| INNO | Behavioural innovation (BINNO) | 0,890 | 0,670 | 0,931 | | 0,887 | |
| | Product innovation (PINNO) | 0,941 | 0,841 | 0,560 | 0,917 | 0,939 | |
| | Process innovation (PROC) | 0,840 | 0,638 | 0,738 | 0,645 | 0,786 | 0,834 |
| | Market innovation (MINNO) | 0,770 | 0,529 | 0,614 | 0,838 | 0,706 | 0,727 |
| BP | Business performance (BP) | 0,889 | 0,671 | | | 0,885 | |

Table 2. CFA Results for Measurement Models.

| Measures | Items | χ^2/df | RMSEA | SRMR | CFI | NFI |
|---------------------------|-------|-------------|--------|--------|-------|-------|
| IT capability (ITC) | 10 | 2,63 | 0,0590 | 0,0299 | 0,990 | 0,985 |
| Innovation (INNO) | 13 | 3,87 | 0,0805 | 0,0426 | 0,980 | 0,974 |
| Business performance (BP) | 4 | 2,49 | 0,0580 | 0,0115 | 0,997 | 0,992 |

RESULTS AND DISCUSSION

To test the proposed hypotheses of this study a structural equation model was estimated. The analysis for the present study was conducted using Lisrel 8,8. Maximum likelihood (ML) method was deployed to estimate the parameter values. Although several methods can be used for the SEM testing, but ML is used most frequently and has the advantage of being statistically efficient. Results are presented in the Table 3.

As Table 3. shows, the overall model demonstrates an acceptable fit. Indices NNFI, CFI, RMSEA, NFI and SRMS are at acceptable levels. Also, χ^2/df is 2,16 is below acceptable cut-off values of 3,00 or 5,00 [20].

Further, the results show that there is a positive and significant relation between IT capability and innovativeness, as it is suggested with H1: $\beta = 0,64, t = 9,27, p < 0,01$. Also, the results show that there is a positive and significant relation between innovativeness and firms' performance: $\beta = 0,51, t = 8,87, p < 0,01$.

Our findings provide empirical support for the relation between IT capability and innovation. IT capability facilitates innovation and indirectly affects firms' performance. This result is consistent with the results of previous work in the literature [21].

Table 3. Hypothesis Testing and GOF Indices for Conceptual Model.

| Hypothesis | Unstandardized estimates | Standardized estimates | t - value | R ² | Result |
|----------------|--------------------------|------------------------|-----------|----------------|----------|
| H1: ITC → INNO | 0,570 | 0,638 | 9,269 | 0,407 | Accepted |
| H2: INNO → BP | 0,909 | 0,511 | 8,869 | 0,262 | Accepted |

$\chi^2 = 680,804; df = 314; RMSEA = 0,0514; SRMR = 0,0558; NFI = 0,970; NNFI = 0,981$ and $CFI = 0,983$

CONCLUSION

This article proposes and tests a model that establishes an integrative view of the links between IT capability, innovativeness and firms' performance. Our findings provide empirical support, for the relation between IT capability and innovativeness in general. IT capability facilitates innovations. This result is consistent with the results of previous results in the literature [12, 22]. Also, this research shows empirically that innovativeness influence firms' performance positively.

As it is stated before, many authors failed to confirm the positive relationship between IT and business performance. In the study [12], it is suggested to find various organizational capacities as important intermediaries between IT and performance. This study contributes to literature confirming innovativeness as a capability that stands between IT capability and firms' performance. This study proposes a contribution to IT research by clarifying the mediating role played by innovativeness in creating and capturing value from information technology. In order to achieve superior business performance and take full advantages of IT possibilities, it is important for managers to understand the role of innovativeness and proposed relations with IT capabilities and performance. The results confirm that ITC, on its own, is insufficient to generate superior business performance. But, IT capability together with organisational culture that promotes innovation will result with firms' success. This article contributes to the RBV showing how the interaction effect of various resources impact firms' performance. Conclusively, this article has sought to advance the existing body of ITC and innovation as important capabilities in the global business arena, supporting premises of RBV. In this article, the definition of ITC has been clarified and its core components have been unearthed.

Although this research makes a significant contribution to the literature and has important managerial implications, it also has several limitations, and our findings must be interpreted in the light of these. The main limitation of this study may be method of sampling, convenience as opposed to random. Also, subjective measures of managers are used for all items. Objective measures would increase the reliability of the results. Furthermore, our findings were drawn from a setting of transitional economy, and should be tested in developed western countries. Future research should incorporate employee-related capabilities in exploring the effects of capabilities on firms' success.

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INSTITUTIONS, EDUCATION AND INNOVATION AND THEIR IMPACT ON ECONOMIC GROWTH

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ABSTRACT

The aim of this article is to provide a closer look of the institutions, their development, education and innovation and their impact on economic growth. The postulates of the neo-classical economic growth theories consider the accumulation of human capital and the technological development as factors that promote economic growth. Thus, investing in education, R&D and innovation is essential for a country's prospects for economic growth. However, the main idea is to present this topic from institutional point of view. By using literature and statistical analysis, the article investigates whether the degree of institutional development in country's educational system is sufficient enough to create prospects for economic growth. We compare four different countries: Macedonia and Serbia as non-EU countries and Bulgaria and Slovenia as EU member countries. We perform two analysis – the first one is comparison of selected statistical data, and the second one is comparison of the Human Development Index for the four countries of interest. The research findings indicate to the fact that institutionalized society with higher degree of institutional development in this case in the educational system is more likely to boost the economic growth. The results also indicate to the fact that societies in which the degree of institutional development is higher, as it is in our case in Slovenia and Bulgaria, are more likely to produce well qualified and skilled labour force which will further impact the economic growth.

KEY WORDS

institutions, education, R&D, innovation, economic growth

CLASSIFICATION

JEL: I25, I28, O43

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INTRODUCTION

In recent years, especially after the latest recession, the issue of economic growth and factors encouraging it became very popular. In the period after WWII, the establishment of the neoclassical economic theory of growth elaborated on the fact that physical and financial capital, labor and technical progress could explain most differences in the rate of economic growth and development between countries¹. Later, in the 1980's, the development of endogenous growth theory introduced the role of innovation² and education³ as significant factors in promoting economic growth and development.

Human capital is the stock of knowledge that people have learned and maintained. The more human capital one economy has the more creative its labor force can be, thus the more prospects for productivity the economy will have. Accordingly, it could be stated that education gives people skills that enable them to be more productive and creative. However, this article tries to identify the factors affecting economic growth from another perspective, a deeper one, which is the impact of institutions and their degree of development. Before proceeding any further it has to be stated that under the term institutional development in this article we use the definition postulated by the Nobel Laureate Douglas North (1991) [1], who defines institutions as clearly defined rules, regulations, norms within the society, or simply as 'rules of the game'. Moreover, this article is based on the assumption that accumulation of human capital can only influence the economic growth, if there is a constant creation of new job vacancies, either through FDIs or investments in R&D and innovation. In order to depict a closer look at the impact of institutional development on economic growth, we try to identify the impact of institutional development on education system in four different countries: Macedonia, Slovenia, Serbia and Bulgaria. The goal of this article is to try to identify the role of institutional development in educational system on economic growth by comparing four different countries. After the introductory part, the article further proceeds with presenting the literature review which has an attempt to present the basic rationale behind the topic. After presenting the literature review in which the institutional development of the four countries of interest is presented, the article explains the basic methodology, thus further proceeds with the presentation of the results followed by brief discussion and finally it finishes with the concluding remarks.

The main background supporting argument in this article is the following one: "the factors we have listed (innovation, economies of scale, education, capital accumulation, etc.) are not causes of growth; they are growth" [2; p.2].



Figure 1. Sequence of causes.

In the previous quote some of the proximate factors, such as innovation, education, capital accumulation are listed which generally corresponds to the factors of production incorporated in the aggregate production function. It has to be pointed out the fact that it is commonly known that the developed countries, and in here we assume as well institutionally developed, experience higher levels of total factor productivity (TFP), more educated workers (human capital) and more machines, tools and factories (physical capital), whilst other countries do not. Thus, the interesting intellectual question, arising from the above view point is why it is that some countries are so much more innovative than others, why they invest much more resources into the educational system, and why people save and invest to accumulate physical capital.

Thus, it is vital to provide a link between the institutions, their development and how its impact through education and innovation promote economic growth.

It could be stated that in almost all countries, governments play a fundamental role in education, health, infrastructure and technology, and policies and expenditures regarding each of these areas. Also, it plays a key role in the balance of spending among these areas, and in that way creates the economy. Briefly speaking, all governments really do have an industrial policy. However, the only difference is among those who construct their industrial policy deliberately, and those who let it be formed by others, usually by particular interests, who view with each other for concealed and open subsidies, for rules and regulations that favor them, usually at the expense of others [3].

Most transition countries have put an attempt in terms of resource constraints and knowledge deficiencies. Their development depends significantly on numerous factors, including the quality of the institutional and regulatory framework and its implementation, the physical infrastructure, the sophistication and depth of financial markets, the quality of educational institutions and labour skills, and the protection of intellectual capital. Greenwald and Stiglitz [3] also state that learning requires resources, including access to capital, which in downturns of the economy is rationed thus investments in R&D are often surrendered. This has an utmost implication for policy: policies which *expose* countries to a high level of instability, or which increase the economy's instability have an unfavorable effect on knowledge. Examples include financial and capital market liberalization and deregulation [4-6], and tariffication [7]. Research shows that societies that have advanced educational systems, in this context it implies institutionalized societies do the best at developing and integrating new technologies into their economies partly because educated workers are more able to think for themselves and solve problems creatively. Government can also play a crucial role in the process of development of technology by providing research and development funds to universities and researchers.

Although, there is not much literature on this specific topic, it has to be stated that [8], claimed that the educational system in Bosnia and Herzegovina lacks a higher degree of institutional development, thus the corporate and business sector are not in a position to invest in R&D and innovation thus, be able to compete in the global and rapidly changing business environment.

EU MEMBER COUNTRIES REPRESENTATIVES

SLOVENIA

Comparing Slovenia to the other transition countries, it has to be claimed that unlike the other transition countries, Slovenia adopted a gradualist approach to privatization from the start. In the period of EU accession the Slovenian policy changed to a larger accent on horizontal industrial policies, and the exclusion of subsidies and state aids for industry in keeping up with the EU release [9]. In the process of synchronizing with the horizontal approach to industrial policy, Slovenia implemented a program for developing industrial clusters connecting companies and research institutes beginning with a pilot program in 2000-2003 [10]. By doing that, it intended to promote knowledge transfer from research institutes to the companies in the cluster. The Slovenian industrial policy focused on support for small firm clusters and networks, throughout a decentralized system of support for innovation using technology parks and university-sponsored by-products [11]. Thus, one might say that the main policy approach was to maintain the old established industrial base though establishing a core of high growth small businesses which would be capable of creating high quality jobs (in terms of value added per worker).

BULGARIA

Bulgaria had a long lived tradition of investing in high tech industries dating back from the communist era when it specialized in computer industries. Even though the large number of

big corporations generally collapsed in the 1990s, a considerable number of high tech SMEs developed with a support from the state [12]. Regarding the final standard annual report in 2005 Bulgaria's industrial strategy generally fulfilled the principles of European industrial policy. In that manner it could be stated that the privatization and reformation process had moved forward and Bulgaria had enhanced the business environment, strengthened the banking sector and attracted foreign investments. Nevertheless, with the intention of completing its preparations for EU accession, Bulgaria was demanded to continue to develop an industrial policy involving promotion of R&D and innovation and reinforce economic competitiveness, complete its privatization strategy as well as the reformation of the steel industry. The EU industrial policy, to which Bulgaria was asked to match, was limited to attracting the competitiveness of enterprises in general, promoting an environment conducive to inventiveness and to the creation of SMEs, and to exploiting the industrial potential of innovation, research and technological development. By 2011, Bulgarian industrial policy was entirely in line with the EU industrial policy reform. This was neatly summarized in the National Reform Programme document for 2010-2013 adopted in April 2011 cited by [13] according to which the government policy in Bulgaria supported R&D and innovations by businesses, increase of the rate of knowledge transfer towards them throughout the development of high-technology parks and technological incubators, centers for transfer of technologies, etc.

NON EU MEMBER COUNTRIES REPRESENTATIVES

MACEDONIA

The current trend of adopting Industrial policy in Macedonia was developed in an attempt to follow the EU horizontal approach, clearly influenced by the EU pre-accession process. The industrial policy of Macedonia according to [14] aims to attract FDI, promote R&D and innovation, promote SME development and entrepreneurship, and develops clusters and associations. The implemented measures are intended to support applied research, development and innovation in industry, encourage knowledge transfer between universities and industry, support industry in employing researchers, motivate transfer of technology, create technological industrial zones, protect intellectual property rights, and develop an integrated innovation policy. The vision of the policy is to encourage the production of higher value-added products and services based on knowledge, innovation and collaboration.

SERBIA

Same as in the case of Macedonia, Serbia is also trying to follow a horizontal industrial policy according to the EU accession requirements. Thus, the industrial policy is focused on creating sustainable industrial growth and development, developing of institutions, improving the investment climate, as well as strengthening the regional and global competitiveness, fostering development of entrepreneurship, increasing and restructuring export, reforms of the educational system in line with needs of the economy, active and dynamic cooperation between science and industry, stimulating the process of innovation, developing of the regional industrial centers and regional business infrastructure.

The industrial policy adopted in Serbia from 2000-2010 inverted the policy of the previous government which had given large subsidies to enterprises in order to maintain employment. It also involved the privatization and restructuring of the economy, attraction of FDI, creation of a competitive business environment, and the escalation of the entrepreneurial sector.

METHODOLOGY

The methodology employed in this article is based on empirically gathered data from the site of World Bank Data Base. We analyze several indicators from the period 2000-2013. We

take the GDP growth as percentage in order to see whether the economy is experiencing growth or decline. Also, we consider as an important factor the population growth, since it can predict the future trends in school enrolment. The primary and tertiary school enrolment rates are found to be crucial for this topic. Also, we consider the FDIs and investments in R&D to see to which degree the countries are institutionalized and whether they follow the EU regulatory postulates. The unemployment rate is also important in this case, especially the unemployment rate of graduate students.

Besides analyzing the aforementioned data, we considered as important factor to compare the Human Development Index (HDI) for these countries and check whether it applies with the results obtained from the above explained variables. The data is obtained from the United Nations Development Programme data set. The HDI is a statistical composition incorporating three statistical measures: life expectancy, education and income per capita.

RESULTS

In the aforementioned reports it was stated that EU representative countries and non EU countries are both following EU directives in terms of boosting the economy to grow. However, the statistics say the opposite. In Macedonia, the data presented in the below Table 1a even though the GDP is in upwards trend, still the investments in FDIs and R&D is still positive but declining. Having the population growth declining, it is reasonable to have a decline in the primary school enrolment. However, it is obvious that there is an increase in the tertiary school enrolment ratio. But, with a declining trend of the population growth and a decline in the primary school enrolment, this number will decline through years. Also, it is vital to state that even though the percentage of FDIs is positive still the country has high unemployment rate, of around 30 % for the analyzed period.

For Slovenia, it is the opposite case, Table 2. The investments in R&D are increasing over time, as well as the enrolment in the tertiary school. Unlike in the case of Macedonia, in which there is no available data for unemployment rate of graduate students, in Slovenia the percentage is high.

In the case of Serbia it is obvious that there is a negative population growth percentage, Table 3. However, the school enrolment in both primary and tertiary has increased over time. The investments in R&D are also increasing over time. There is no availability of data for the unemployment rate of the graduate students enrolled in the tertiary schools.

On the other side, the case of Bulgaria is very similar to Slovenia, Table 4. Both countries as EU member countries, as following the regulative postulates that the countries have to have institutional developments, in our case, have to have investments in the R&D sector, and tend to invest in education.

In Table 5, statistical representation of Human Development Index (HDI) for the four countries of interest is presented. Besides that, information is given of the proxy level of how high or low the Human Development is for one country.

Except for Slovenia which according to the data in the above table is considered as to have very high human development, the other three countries Bulgaria, Serbia and Macedonia are considered as to have high human development. The most development through time has Bulgaria, since the 1980s, when the country has medium human development, in the 1990s it reached a point in which now it is considered as to have high development. However, for Slovenia, Serbia and Macedonia the data from the 1980s is missing.

Considering what was stated in the introductory part, given the fact that the HDI is composed of life expectancy, education and income per capita, it can also be connected to the level of institutional development. Thus, the same conclusion can be drawn as from the previous analysis, Slovenia shows the highest level of institutional development given the data analyzed.

Table 1. Macedonia. Source: World Bank Database.

| Variable | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--|---------|---------|--------|--------|--------|--------|--------|-------|-------|---------|--------|-------|---------|-------|
| GDP growth (annual %) | 4.54914 | -3.0672 | 1.494 | 2.2222 | 4.6744 | 4.7234 | 5.137 | 6.473 | 5.472 | -0.3586 | 3.3588 | 2.34 | -0.4562 | 2.666 |
| Population growth (annual %) | 0.86341 | 0.62999 | 0.4514 | 0.3092 | 0.2334 | 0.2067 | 0.1796 | 0.135 | 0.102 | 0.0852 | 0.0789 | 0.08 | 0.0801 | 0.075 |
| Foreign direct investment, net inflows (% of GDP) | 5.70011 | 12.0532 | 2.6273 | 2.3808 | 5.6844 | 2.3221 | 6.2299 | 8.798 | 6.173 | 2.7605 | 3.2044 | 4.84 | 3.4128 | 3.84 |
| School enrollment, primary (% gross) | 95.6998 | 93.4475 | 92.643 | 91.289 | 91.898 | 93.416 | 93.542 | 93.9 | 90.13 | 90.202 | 90.091 | / | 89.254 | / |
| School enrollment, tertiary (% gross) | 22.6325 | 24.5213 | 26.994 | 27.444 | 28.024 | 29.63 | 28.986 | 34.79 | 39.11 | 38.983 | 37.075 | / | 38.458 | / |
| Unemployment, total (% of total labor force) (national estimate) | 32.2 | 30.5 | 31.9 | 36.7 | 37.2 | 37.3 | 36.025 | 34.93 | 33.76 | 32.179 | 32.02 | 31.38 | 31.016 | 29 |
| Unemployment with tertiary education (% of total unemployment) | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Employment in industry (% of total employment) | / | / | 33.3 | 33.9 | 32.8 | 32.3 | 32.6 | 31.3 | 31.3 | / | / | 30 | 29.9 | / |
| Research and development expenditure (% of GDP) | 0.44059 | 0.31635 | 0.2593 | 0.2191 | 0.2395 | 0.2386 | 0.2027 | 0.175 | 0.225 | 0.1987 | 0.2179 | / | / | / |

Table 2. Slovenia. Source: World Bank Database.

| Variable | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--|---------|---------|---------|---------|--------|--------|--------|--------|-------|--------|--------|-------|--------|--------|
| GDP growth (annual %) | 4.15549 | 2.94951 | 3.83613 | 2.84241 | 4.3517 | 4.003 | 5.6561 | 6.9415 | 3.3 | -7.797 | 1.2218 | 0.613 | -2.64 | -0.998 |
| Population growth (annual %) | 0.29607 | 0.1575 | 0.12392 | 0.0603 | 0.0641 | 0.1732 | 0.3191 | 0.5592 | 0.158 | 0.9039 | 0.4361 | 0.208 | 0.21 | 0.1357 |
| Foreign direct investment, net inflows (% of GDP) | 0.66758 | 2.41145 | 7.04264 | 1.01524 | 2.4119 | 2.6709 | 1.7611 | 3.8836 | 1.987 | -0.7 | 0.635 | 1.728 | 0.0778 | 0.1771 |
| School enrollment, primary (% gross) | 96.7904 | 100.43 | 104.109 | 109.204 | 120.4 | 98.784 | 100.06 | 96.781 | 97.31 | 97.912 | 98.218 | 98.45 | 98.93 | 98.784 |
| School enrollment, tertiary (% gross) | 55.1109 | 60.3339 | 66.3009 | 69.1475 | 72.681 | 79.708 | 83.14 | 84.905 | 85.55 | 86.119 | 88.468 | 85.09 | 86.025 | 84.41 |
| Unemployment, total (% of total labor force) (national estimate) | 6.9 | 5.7 | 6.3 | 6.7 | 6.3 | 6.5 | 6 | 4.8 | 4.4 | 5.9 | 7.2 | 8.2 | 8.8 | 10.1 |
| Unemployment with tertiary education (% of total unemployment) | 4.3 | 5.2 | 3.5 | 6.3 | 8.2 | 8.6 | 11.5 | 14.6 | 16.3 | / | / | / | / | / |
| Employment in industry (% of total employment) | 37.4 | 38.1 | 38.6 | 36.9 | 35.9 | 37.2 | 35 | 34.2 | 35 | 33 | 32.5 | 31.5 | 30.8 | / |
| Research and development expenditure (% of GDP) | 1.38087 | 1.49473 | 1.46527 | 1.26862 | 1.3936 | 1.4371 | 1.5581 | 1.4481 | 1.655 | 1.8603 | 2.1062 | 2.474 | 2.7995 | / |

Table 3. Serbia. Source: World Bank Database.

| Variable | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--|---------|--------|--------|--------|--------|--------|--------|--------|---------|--------|--------|--------|--------|--------|
| GDP growth (annual %) | 6.0383 | 3.7989 | 4.4802 | 5.357 | 6.5597 | 5.9553 | 6.4704 | 6.9074 | 5.7547 | -5.012 | 0.6553 | 1.982 | 0.4922 | 1.0659 |
| Population growth (annual %) | -0.4939 | -1.852 | -1.911 | -0.572 | -0.543 | -0.532 | -0.53 | | -0.7019 | -0.644 | -0.658 | -0.641 | -0.579 | -0.56 |
| Foreign direct investment, net inflows (% of GDP) | 7.4999 | 5.6834 | 5.5354 | 9.937 | 10.271 | 13.987 | 23.401 | 31.797 | 19.312 | 7.7683 | 3.8353 | 3.8093 | 3.0011 | 3.4649 |
| School enrollment, primary (% gross) | 104.32 | 105.8 | 104.98 | 105.9 | 105.12 | 101.21 | 98.656 | 100.42 | 101.53 | 102.74 | 103.2 | 100.93 | 99.528 | 99.245 |
| School enrollment, tertiary (% gross) | 44.491 | 43.018 | 40.864 | 41.52 | 41.938 | 44.272 | 45.82 | 49.535 | 51.351 | 54.1 | 57.993 | 59.625 | 62.696 | 66.495 |
| Unemployment, total (% of total labor force) (national estimate) | 16.218 | 19.921 | 18.11 | 13.73 | 12.037 | 10.083 | 8.9507 | 6.8777 | 5.6095 | 6.8166 | 10.234 | 11.26 | 12.27 | 12.941 |
| Unemployment with tertiary education (% of total unemployment) | 8.4 | 10.3 | 10.3 | 11.9 | 11.4 | 10.3 | 10.7 | 8.6 | 10.1 | | | | | |
| Employment in industry (% of total employment) | 32.7 | 32.7 | 32.6 | 32.1 | 32.9 | 34.2 | 34.5 | 35.5 | 36.4 | 35.2 | 33.3 | 31.5 | 31.3 | |
| Research and development expenditure (% of GDP) | 0.5083 | 0.4572 | 0.4771 | 0.483 | 0.4872 | 0.4576 | 0.4577 | 0.4537 | 0.4702 | 0.5285 | 0.5979 | 0.5704 | 0.6392 | |

Table 4. Bulgaria. Source: World Bank Database.

| Variable | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--|---------|---------|---------|---------|--------|-------|--------|---------|---------|--------|--------|--------|--------|---------|
| GDP growth (annual %) | 7.7592 | 4.99271 | 7.1158 | 4.4154 | 9.0465 | 5.54 | 4.9043 | 5.8888 | 5.3667 | -3.116 | 0.5845 | 1.401 | -1.015 | 2.5717 |
| Population growth (annual %) | -0.3195 | -0.1719 | -0.0453 | -0.2595 | -0.233 | -0.3 | -0.393 | -0.4055 | -0.4257 | -0.401 | -0.402 | -0.789 | -0.485 | -0.4866 |
| Foreign direct investment, net inflows (% of GDP) | 0.7933 | 1.44682 | 3.5201 | 6.6354 | 4.1352 | 7.812 | 16.231 | 8.5181 | 6.0829 | 4.5419 | 3.3963 | 5.812 | 2.9104 | 4.3373 |
| School enrollment, primary (% gross) | 103.59 | 102.521 | 102.12 | 101.07 | 101.55 | 102.7 | 101.84 | 101.06 | 100.63 | 97.686 | 95.896 | 94.88 | 92.962 | 100.9 |
| School enrollment, tertiary (% gross) | / | 37.7619 | 35.664 | 39.613 | 40.934 | 44.21 | 46.82 | 47.993 | 48.665 | 49.85 | 49.083 | 50.37 | 52.377 | 56.381 |
| Unemployment, total (% of total labor force) (national estimate) | / | / | / | / | 18.5 | 20.8 | 20.8 | 18.1 | 13.6 | 16.6 | 19.2 | 23 | 23.9 | 22.12 |
| Unemployment with tertiary education (% of total unemployment) | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Employment in industry (% of total employment) | / | / | / | / | 26.9 | 27.6 | 29.3 | 29.5 | 26.2 | 25.1 | 26 | 26.8 | 26.5 | / |
| Research and development expenditure (% of GDP) | 0.9656 | 0.34591 | 0.7252 | 0.5651 | 0.32 | 0.434 | 0.4889 | 0.3624 | 0.3848 | 0.9171 | 0.7921 | 0.777 | 0.9868 | / |

Table 5. Human Development Index. Source: United Nations Development Programme.

| HDI Rank | Country | 1980 | 1985 | 1990 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|----------|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| .. | Very high human development | 0.757 | 0.775 | 0.798 | 0.849 | 0.870 | 0.874 | 0.877 | 0.879 | 0.880 | 0.885 | 0.887 | 0.889 | 0.890 |
| .. | High human development | 0.534 | 0.552 | 0.593 | 0.643 | 0.682 | 0.691 | 0.701 | 0.710 | 0.715 | 0.723 | 0.729 | 0.733 | 0.735 |
| .. | Medium human development | 0.420 | 0.448 | 0.474 | 0.528 | 0.565 | 0.573 | 0.580 | 0.587 | 0.593 | 0.601 | 0.609 | 0.612 | 0.614 |
| .. | Low human development | 0.345 | 0.365 | 0.367 | 0.403 | 0.444 | 0.456 | 0.465 | 0.471 | 0.478 | 0.479 | 0.486 | 0.490 | 0.493 |
| 25 | Slovenia | .. | .. | 0.769 | 0.821 | 0.855 | 0.861 | 0.865 | 0.871 | 0.875 | 0.873 | 0.874 | 0.874 | 0.874 |
| 58 | Bulgaria | 0.658 | 0.679 | 0.696 | 0.714 | 0.749 | 0.753 | 0.759 | 0.766 | 0.767 | 0.773 | 0.774 | 0.776 | 0.777 |
| 77 | Serbia | .. | .. | 0.726 | 0.713 | 0.732 | 0.735 | 0.739 | 0.743 | 0.742 | 0.743 | 0.744 | 0.743 | 0.745 |
| 84 | Macedonia | .. | .. | .. | .. | 0.699 | 0.705 | 0.708 | 0.724 | 0.725 | 0.728 | 0.730 | 0.730 | 0.732 |

DISCUSSION

From the results of this study we can state that the higher the institutional development higher the prospects for economic growth. The countries that are EU members are more institutionalized, have lower unemployment rate, higher investments in the R&D but lower FDIs. They seem to manage to follow their created industrial policies, unlike the case of non EU countries, Macedonia and Serbia. The study has several limitations. First, for the case of Macedonia and Serbia we have missing data, from the separate analyzes. In the analyzes of the Human Development Index, most data is provided for Bulgaria, so the level of development could be observed in a more clear way. Moreover, the study should be based on analyzing more factors, not the selected ones, in order to depict the total degree of institutional development. The selected countries are not very transparent in their data.

CONCLUSION

Having clearly defined rules and regulations, meaning having institutionalized societies, the country can experience prospects for future economic growth. The human capital can have an impact on economic growth only if there is a creation of new job vacancies and higher absorption power for employment. If that is not the case, the country could experience tendencies towards Brain-gain and Brain-drain. Considering the last statement, it could be concluded that by having high enrolment rate in the graduate schools, and having high investments in the R&D and higher degree of attraction of FDIs, the country can experience high economic growth, if the institutions are developed, *ceteris paribus*. The prospects for further research might include the issue of Brain gain or Brain drain, since it is the usual occurrence in the developing countries. In the case of Macedonia and Serbia as non EU members countries, it could be easily measured the mobility of citizens that emigrated in order to gain better education and experience in the Western countries.

REMARKS

¹We refer to the Solow model developed in 1953.

²We refer to the model developed by Arrow and Romer 1986.

³We refer to the model developed by Lucas 1988 – the first three quotations are not in the reference list.

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IMPACT OF COMMITMENT TO BUSINESS ETHICS TO NONFINANCIAL BUSINESS PERFORMANCE

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ABSTRACT

The article investigates the relationship between commitment to business ethics and nonfinancial business performance. Data of commitment to business ethics and nonfinancial business performance were collected from 100 participants through a questionnaire survey. The survey was conducted in 2015 in Croatian large and medium sized companies. The questionnaire for assessing commitment to business ethics contained nine different dimensions while the nonfinancial business performance contained three dimensions: client satisfaction, human resource management plus innovativeness and efficiency of business processes. Multiple regression methods were applied in the analysis. The empirical results of three multiple linear regression models show that certain dimension of commitment to business ethics had a positive influence on the nonfinancial performance of the companies. Motivation and rewarding policy for ethical behavior and responding to unethical behavior, as a dimension of commitment to business ethics, has distinctive effects on all three nonfinancial performance dimensions. It was also found that selecting suppliers based on the standards of ethics and compliance has a positive and strong influence on client satisfaction while using ethical criteria in the performance and efficiency evaluation of employees has a positive and significant influence on innovativeness and efficiency of business processes. This research leads to the conclusion that some dimensions of commitment to business ethics can be important predictors of nonfinancial business performance. Therefore, results of the research could be considered as valid motivation for further improvement of commitment to ethics in the business environment.

KEY WORDS

business ethics, business performance, commitment to business ethics, multiple regression, nonfinancial dimension

CLASSIFICATION

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INTRODUCTION

In the last decades, researchers spent a considerable amount of study on the topic on a commitment to business ethics in the nonfinancial perspectives of business performance. While some authors, in terms of nonfinancial dimensions, argue the ethics is a good business investment because it creates positive external impacts such as the stakeholder's commitment and trust which in turn guarantees the long-term positive results [1], enhanced reputation and positive corporate image [2], increase customer loyalty [3] and build competitive advantage [4], others are skeptical [5]. Berrone et al. [6] shows that companies with substantial ethical commitment reach a higher satisfaction of stakeholders which ultimately has a stronger influence on financial result stated in market value added. Companies committed to business ethics provide a clear view of their values and beliefs, avoiding uncertainty of the future performance and finally risks in the long-term [7] and, therefore, they attract investors who recognize ethical and sustainable priorities in business [8]. Furthermore, in companies committed to business ethics employees' perception is positively related to job satisfaction [9] trust in the organizations [10], effective communication between managers and employees [10] and ethical decision-making [11]. This indicates that a strong commitment to business ethics creates positive and healthier organizational culture. In the research, Trevino et al. [12] connected affirmative ethical cultures to decreased misconduct, reduced pressure to compromise ethical standards, increased reporting to top-level management and their response to misconducts, higher satisfaction within the company and greater willingness to handle misconduct in general [13].

After numerous scandals and unethical activities, it has been noticed that a number of companies have developed ethics programs, but they were frequently just "window dressing" for the public. Therefore, some governments wanted to introduce changes in this segment and legally regulate it. After the adoption of the US Foreign Corrupt Practices Act (FCPA) 1977 when ethics and compliance programs were first introduced into business practices, the U.S. Sentencing Commission [14] included revisions to their guidelines for developing an organizational culture that promotes ethical conduct and complies with the laws in companies. However, up to date, no country in the world is excluded from unethical activities and misconducts including the US, which legislation of ethics and compliance is on the highest level. According to Bajaj et al. [15] the total fines for FCPA enforcement imposed on companies from 2002 through 2009 ranged from under \$1 million to nearly \$156 million annually. Authors also stated that in 2013, the settlement resulted in fines close to \$400 million. Research noted that between largest ten FCPA settlements, just two companies were from the US, other eight companies were from other countries such as Germany, India, France, Italy, Hungary and UK [15] which confirms that the unethical actions are widespread. On the other hand, increased interest in business ethics became obvious in all economies around the world. Recent researches confirm that commitment to business ethics have strong impression in business [16-18]. Many companies recognize their importance and according to IT Policy Compliance Group [19], commitment to ethical business have strong impression on: (i) 17 % higher revenues than all other firms; (ii) 14 % higher profits than all others; (iii) 18 % higher customer satisfaction rates; (iv) 17 % higher customer retention levels; (v) 96 % lower financial losses from the loss of theft of customer data; (vi) 50 times less likely to lose or have stolen customer data; and (vii) 50 % less spent on regulatory compliance annually. According to the National Business Ethics Survey [20], increasingly sophisticated ethics programs are developing new standards in employee's behavior. Companies are working hard to implement ethical standards and to build strong cultures. The survey confirmed if companies evaluate ethical performance and build strong cultures,

misconduct is substantially lower [20]. According to their survey, 20 % employees reported seeing misconduct in companies where cultures are “strong” compared to 88 % who witnessed wrongdoing in companies with the weakest cultures.

Nowadays, ethical business has emerged as an essential component in the long-term business success, and it becomes an important issue in society, which give us a justified reason to explore its function in the corporate governance and performance of companies in modern market conditions. With ethical commitment, companies can avoid negative effects on their business in the long term. While commitment to business ethics is dominant on regulated western markets, too little attention has been paid to this subject in transition countries, including Croatia. Standards that encourage commitment to business ethics in regulated markets (e.g., US FCPA, USSC, UK Anti-bribery Act) present significant challenge for Croatian companies when they operate abroad due to an absence of additional local legislation that encourages companies to implement ethical standards in their daily activities.

Based on the analysis of previous studies and limited studies that analyze the impact of business ethics on overall performance and specifically nonfinancial perspectives of business performance, authors concluded that there was a need for additional research in that field. Authors would like to close this gap and contribute to the body of literature by measuring an impact of business ethics on nonfinancial performance in Croatian companies. Article consists on the introduction, followed by the literature review. In the third part of the article methodology is presented, while results are presented in the fourth part of the article, followed by the conclusion.

LITERATURE OVERVIEW

Even though the concept of business ethics has been presented throughout the whole history of doing business, in the late 1970s it has begun to institutionalize in business and academic world. It has emerged as an interdisciplinary field which implies that more than forty years scientific and researchers studying the problems and phenomena of business ethics, and their influences and functions in the process of corporate governance and business performance.

THE NOTION OF BUSINESS ETHICS

Business ethics represents good or bad and right or wrong behavior towards all stakeholders in business context, and it deals with moral expectations and practices occurring in economic system. Social responsibility as the issue of external demonstration of ethical performance depends on internal organizational ethics based on in-depth ethical standards and organizational culture that supports acting well. Therefore, those principles through ethical standards need to become a part of every company. Although a large number of authors and researchers denies beliefs of those who argue that ethics and business are excluded [21], Trevino and Nelson [22] define business ethics as a set of moral rules and values that influence and direct the behavior of individuals or groups in relation to something that is right or wrong in making decisions and in the management. Drucker, considered as the founder of modern American management, [23] also recognized the interrelation between ethics and business. He argued that business ethics is not separate from any other kind of ethics. He explained that: “All authorities of the Western tradition – from the Old Testament prophets all the way to Spinoza in the seventeenth century, to Kant in the eighteenth century, Kierkegaard in the nineteenth century and, in this century, the F.H. Bradley (1927) (Ethical Studies) or the American Edmond Cahn (1955) (The Moral Decision) – are, however, in complete agreement on one point: There is only one ethics, one set of rules of morality, one code, that of individual behavior in which the same rules apply to everyone alike” [24]. This

kind of universal ethics makes an imperative of social responsibility that offers primacy in long-term sustainable business. Therefore, many authors and entrepreneurs point out that business ethics improves sustainable business performance and provides operational excellence to every business person [25].

MEASURING INTENSITY OF COMPANY'S COMMITMENT TO BUSINESS ETHICS

Though there is no universal measure of business ethics, recently, authors have set different criteria to measure the intensity of company's commitment to business ethics. Trevino et al. [26] in their research used fourteen dimensions in terms of leadership role modeling, ethics code, sanctions for ethical and unethical conduct and norms of ethical behavior in the company. Vig [27] developed a model that assist in establishing an ethical organisational culture with determined criteria of business ethics in terms of values, implementation and governance of such a company. Furthermore, Lloyd and Mey [28] include in their model code of ethics, top management commitment, reward system, ethics training, helpline, whistle-blower protection, ethical assessment and audit and ethics committee.

Berrone et al. [6] determine two dimensions of Corporate Ethical Identity (CEI). The first dimension named Corporate Revealed Ethics (CRE) is more focused on transparent communication of ethics, commonly, through the company's statement. The second dimension refers to Corporate Applied Ethics (CAE) which incorporates ethical activities like actions, events and process based on ethics, employee's profit sharing and training programs [6]. Additionally, Verbos et al. [29] define the living code, which includes a synergy of authentic leadership, as an ethical organizational culture and five key organizational processes.

Trevino and Nelson [22] identify that companies create an ethical culture through a multiple interrelation of formal (rules, policies and codes, executive leader communications, orientation and training programs, selection systems, performance management systems, organizational structures, and formal decision-making process) and informal organizational systems (norms of daily behavior, stories heroes, rituals, myths and role models, and language). It can be concluded that companies differ precisely in line with the values prevailing in their way of doing business inside a company and towards all stakeholders in the system. Based on previous research, in our study, authors determinate nine dimensions for measuring commitment to business ethics in terms of motivation and rewarding policy for ethical behavior and responding to unethical behavior; communicating ethical values within the company; promoting an ethical culture, having an unambiguous, visible commitment and involvement in solving ethical problems by senior management; using ethical criteria in performance and efficiency evaluation of employees; using ethical criteria in risk assessment; implementing and integrating ethical criteria in organizational culture; using ethical criteria in corporate reporting to external stakeholders; selecting suppliers based on the standards of ethics and compliance; and conducting due diligence in terms of ethics and compliance in mergers and acquisitions.

A crucial dimension of ethical commitment in a company is an implemented policy of motivation and rewarding for ethical behavior and responding to unethical behavior [22]. For ethical values to be effectively communicated throughout a company, companies should ensure that employees understand and follow the values, rules and codes of conduct. Companies encourage employees to speak up and use company values as a framework for decision making [30] which is also a part of integrated ethical communication. Internal communication aims at enlivening set codes and procedures and encouraging management-level and other employees to exhibit their ethical actions in their relations and communication.

Top-level management, including board and senior managers, is responsible for ensuring that a company has effective ethics program, and they need to set the highest standards of ethical

behavior. By following the principle “tone of the top”, they allow ethical behavior standards to cascade to the middle management who then, through their actions and behaviors, set an example for other managers and employees, thus affecting their behavior. On paper, a company can have all other dimensions of the effective, ethical program, but if it lacks top-level commitment, it is hardly possible to develop a commitment to business ethics.

Furthermore, to assess the efficiency of employee’s performance and prevent possible non ethical activities, companies need to ingrain ethical criteria in performance and efficiency evaluation of employees. Steinberg [31] argues that ethics is the most effective when supervisory and management personnel, closest to the action, are aware of the employee activities and monitor them in the usual course of managing a business. Using ethical criteria in performance and evaluation of employee influence on how they do their job and how they interact with their colleagues and other stakeholders is the significant indicator of ethical importance.

Due to increased business performance in highly regulated markets and stakeholders’ interest in the way of doing business, companies are compelled to use ethical criteria in risk assessment to maintain the competitive position on the market. Therefore, there is a need to assess risks in that segment. According to Williford and Small [32] ethical criteria as a part of ethics and compliance risk assessments usually include possible sanctions and penalties on local and international markets, employee complaints, audit results, corruption and practices of countries where domicile companies work and court judgments.

Company with ethical codes and procedures requires a commitment to employee’s ethical behavior. Therefore, codes and policies that specify acceptable and unacceptable types of behavior in companies should be a guiding principle of ethical organizational behavior. Taking into consideration the necessity of ethical procedures to have a strong culture, it can be concluded that a strong, ethical organizational culture can be established only with clearly defined codes, policies and procedures of ethical behavior and with clearly and transparently implemented communication on all organizational levels.

Ethical criteria for corporate reporting also present an opportunity to develop a positive reputation of the company. Companies are dependent on how their stakeholders perceive them, therefore, managers need to communicate not just performance results, but also their achievement to key stakeholders to strengthen the reputation and goodwill and finally ensure better access to capital and foreign investments. Ethical companies increasingly require their partners and suppliers to develop their ethical standards or to comply with company’s standards what makes an ethical base for selecting suppliers.

Finally, due diligence, often part of a wider organizational due diligence framework, is a form of ethics and compliance risk assessment with the purpose to prevent and mitigate risk [33]. Companies are especially empowered to use due diligence when starting new business relationships and entering new markets to take measures to prevent possible non ethical and noncompliance activities on time.

IMPACT OF BUSINESS ETHICS TO BUSINESS PERFORMANCE

Making decisions based only on financial indicators as a reflection of past events are no longer sufficient for achieving sustainable competitive advantage. Therefore, companies focus on the parameters that create long-term value including nonfinancial indicators as indicators of business performance [34]. Nowadays the majority of companies present nonfinancial indicators, essential for their business processes, such as customer perspective, product quality, the duration of the operating cycle, internal processes, innovation and employee satisfaction, and learning and growth perspective in their annual report.

There are many models that incorporate financial and nonfinancial perspective in assessing the performance of the company (e.g., Balanced Scorecard, EFQM Excellence Model, Value Based Management, Business Excellence Model, Total Quality Management, Activity Based Costing, Key Performance Indicator). Some researchers have investigated the relationship between nonfinancial performance as a result of business ethics and financial performance of companies. Although it was the considerable amount of positive relationship [6, 35], studies also have shown the negative relationship [36] and non-significant relationship [37, 38]. Verschoor [39] made the first study which investigated the relationship between company's financial and nonfinancial performances and commitment to business ethics.

In the line of Verschoor's paper, authors would like to contribute to this kind of literature by investigating an impact of business ethics on nonfinancial performance in Croatian companies measured regarding client satisfaction, human resources management plus innovativeness and efficiency of business processes. Client and customer satisfaction as a nonfinancial business performance present an important issue in evaluating company's performance which leads to trust and loyalty in long-term. Although the characteristics of human resource management are regarded to play significant roles in encouraging ethical organization, few empirical studies have been conducted [40]. Furthermore, there are very few studies examining the role of innovation in the contest of business ethics [41]. Therefore, this study will suggest that a company's innovation will be influenced by a commitment to business ethics.

HYPOTHESIS DEVELOPMENT

Companies that do not motivate and reward their employees with incentives based just on the job results, such as increased sales or profit and instead use ethical and moral attributes to verify how employees perform, prove the importance of the way their employees do things, not just what they achieve [22]. Companies revealed what desired employees behavior is and which unethical behavior they discourage. Emphasizing the importance of motivation, rewarding policy for ethical behavior and responding to unethical behavior is crucial to the alignment an ethical culture in a company [22]. Hence, we propose:

H1: There is a positive relationship between motivation and rewarding policy for ethical behavior and responding to unethical behavior as a dimension of commitment to business ethics and nonfinancial business performance.

Reputation is a key factor for profitability and sustainability from stakeholder perspective [42]. Companies with a good reputation may also expect client loyalty resulting in a more stable or increase in turnover over time. Companies that take into consideration their ethical reputation want to know with whom they do business and want to be sure which level of ethical standards in doing business their partners and suppliers use. In order to do business with them, companies increasingly require their partners and suppliers to develop their own ethical standards or to comply with company's own standards. Harmonized standards of ethics and compliance enable business partners to demonstrate mutual respect and trust which is essential for developing a long-term sustainable cooperation. Hence, we propose:

H2: There is a positive relationship between selecting suppliers based on the standards of ethics and compliance as a dimension of commitment to business ethics and client satisfaction as a nonfinancial business performance.

According to the National Business Ethics Survey [20], 67 % companies included ethical conduct as a performance measure in employee evaluations and 74 % companies communicated internally about disciplinary actions when wrongdoing occurs. These companies discipline employees' misconduct and letting it be known that bad behavior is being punished. Data showed that discipline and ethics as a part of employee evaluations are

two of the most powerful tools in effective ethics programs [20] which have the purpose of encouraging trust and loyalty among employees [43]. Commitment to business ethics has a positive impact on job satisfaction and organizational commitment [10, 26, 44], increased attraction of high-potential talent [45], and finally on innovations [41]. Therefore, in line with the previous research, we propose:

H3: There is a positive relationship between using ethical criteria in performance and efficiency evaluation of employees as a dimension of commitment to business ethics and innovativeness and efficiency of business processes as a nonfinancial business performance.

METHODOLOGY

SAMPLE

Data were collected from Croatian companies included in the Croatian Financial Agency (FINA) database, the largest database of Croatian firms. The size was the only criteria for inclusion of companies in the sample, where medium-sized companies have from 50 to 249 employees, and large have 250 or more employees. As per the FINA database, the total number of firms amounted to 101 191, out of which 1268 medium and 350 large firms. The planned sample size was 600 companies. The total sample was equally allocated in large and medium companies, so the sample randomly included 300 medium and 300 large companies. Due to the complexity of the criteria that determine commitment to business ethics, which do not appear widely in such a form in smaller companies, from the research was exempted small companies up to 49 employees. Data were collected in a way that the companies selected in the sample in the first phase were contacted by telephone. In the next phase, the contact was reached via e-mail address, where also a questionnaire in electronic format was sent. Within the three months, a total of 100 completed questionnaires were collected (included 52 medium and 48 large companies). It should be noted that due to the specific topic, and the absence of a legal obligation to implement an ethical program in Croatian companies, the return of the questionnaire of 16,67 % for this survey is satisfactory. From the total of 100 participated companies, 88 were private companies and 12 state-owned companies.

Characteristics of the participants were collected as part of the survey. Data on gender, grade, and field of education were obtained through surveys. Among the respondents, 64 % were female, and 36 % were male in large companies; 67 % were female, and 33 % were male in medium-sized companies; 66 % had, at least, university degree in large companies and 44 % in medium-sized companies; 18 % had education in management of large companies and 35 % of medium-sized companies.

MEASURES

Our research instrument consisted of three sets of questions: (i) commitment to business ethics, (ii) nonfinancial dimensions of business performance, (iii) the demographics of subjects and companies. Questions were asked in the following forms: closed questions with a selection of one or more predefined answers, questions where respondents expressed agreement with a particular statement using 5-point Likert scale and open-ended questions. Respondents were guaranteed anonymity. Items for assessing commitment to business ethics were developed after examining the issues covered by various researches [6, 26-29]. In our study we determined the following dimensions for measuring commitment to business ethics: (i) motivation and rewarding policy for ethical behavior and responding to unethical behavior; (ii) communicating ethical values within the company; (iii) promoting an ethical culture, having an unambiguous, visible commitment and involvement in solving ethical problems by senior management; (iv) using ethical criteria in performance and efficiency

evaluation of employees; (v) using ethical criteria in risk assessment; (vi) implementing and integrating ethical criteria in organizational culture; (vii) using ethical criteria in corporate reporting to external stakeholders; (viii) selecting suppliers based on the standards of ethics and compliance; and (ix) conducting due diligence in terms of ethics and compliance in mergers and acquisitions.

After investigating nonfinancial indicators in various businesses performance models [46-48], the data of nonfinancial business performance were determined with the following dimensions: (i) client satisfaction; (ii) human resources management; and (iii) innovativeness and efficiency of business processes. Each dimension was calculated as the average value of three variables. Therefore, client satisfaction consists: CS_1 (Customer satisfaction), CS_2 (Market share) and CS_3 (Quality of products and services). Human resources management was calculated as the average value of HR_1 (Employee productivity), HR_2 (Employee loyalty) and HR_3 (Employee turnover). Innovativeness and efficiency of business processes was calculated as the average value of three variables: IE_1 (The efficiency of internal processes), IE_2 (Innovation of products and services) and IE_3 (Internal processes innovation). The aim of the research is to study the impact of business ethics commitment, as the independent variable, on the nonfinancial performance of the Croatian companies as the dependent variable, shown in more detail in Table 1.

FINDINGS

Tables 2, 3 and 4 represent the regression models with three dependent variables: Client satisfaction, Human resources management and Innovativeness plus efficiency of business processes and independent variables BE_1 to BE_9, which indicate ethics commitment. A positive correlation between Motivation and rewarding policy for ethical behavior and responding to unethical behavior as an indicator of business ethics commitment has a positive statistically significant impact on the Client satisfaction, Human resources management, and Innovativeness plus efficiency of business processes which implied that ethical context has a positive impact on all nonfinancial business performance dimensions. Therefore, the first hypothesis is confirmed, and there is a positive relationship between motivation and rewarding policy for ethical behavior and responding to unethical behavior as a commitment to business ethics and nonfinancial business performance.

Table 2 represents the regression model with the dependent variable Client satisfaction, and independent variables BE_1 to BE_9, which indicate ethics commitment. A positive correlation was found between commitment to business ethics and Client satisfaction. The results revealed that two variables of Motivation and rewarding policy for ethical behavior and responding to unethical behavior (10 %) and Selecting suppliers based on the standards of ethics and compliance (5 %) has a positive statistically significant impact on the Client satisfaction. The model explains 26,2638% of the variability of the dependent variable Client satisfaction. Heteroscedasticity is not present (White's test LM = 52,2621; Breusch-Pagan LM = 1,86902), and that residuals are normally distributed (p -value = 0,157167). Therefore, the second hypothesis is confirmed, and there is a positive relationship between selecting suppliers based on the standards of ethics and compliance as a dimension of commitment to business ethics and client satisfaction as a dimension of nonfinancial business performance.

Table 3 shows the regression model with the dependent variable Human resources management, and independent variables BE_1 to BE_9, which indicate ethics commitment. The results revealed that the variable of motivation and rewarding policy for ethical behavior and responding to unethical behavior (1 %) has a positive statistically significant impact on the Human resources management. The model explains 31,6860 % of the variability of the dependent

Table 1. Research instrument description.

| Independent variables | | | |
|--|--|--|--------------------------------------|
| | Code | Dimensions | |
| Commitment to business ethics | BE_1 | Motivation and rewarding policy for ethical behavior and responding to unethical behavior | |
| | BE_2 | Communicating ethical values within the company | |
| | BE_3 | Promoting an ethical culture, having an unambiguous, visible commitment and involvement in solving ethical problems by senior management | |
| | BE_4 | Using ethical criteria in performance and efficiency evaluation of employees | |
| | BE_5 | Using ethical criteria in risk assessment | |
| | BE_6 | Implementing and integrating ethical criteria in organizational culture | |
| | BE_7 | Using ethical criteria in corporate reporting to external stakeholders | |
| | BE_8 | Selecting suppliers based on the standards of ethics and compliance | |
| | BE_9 | Conducting due diligence in terms of ethics and compliance in mergers and acquisitions | |
| Dependent variables | | | |
| | Code | Dimensions | |
| Nonfinancial business performance | Client satisfaction | CS_1 | Customer satisfaction |
| | | CS_2 | Market share |
| | | CS_3 | Quality of products and services |
| | Human resources management | HR_1 | Employee productivity |
| | | HR_2 | Employee loyalty |
| | | HR_3 | Employee turnover |
| | Innovativeness and efficiency of business processes | IE_1 | The efficiency of internal processes |
| | | IE_2 | Innovation of products and services |
| | | IE_3 | Internal processes innovation |

variable Human resources management. Heteroscedasticity is not present (White's test LM = 48,4853; Breusch-Pagan LM = 12,0142), and that residuals are normally distributed (p -value = 0,962229). The regression model made a contribution to the first hypothesis.

Table 4 presents the regression model with the dependent variable Innovativeness and efficiency of business processes, and independent variables BE_1 to BE_9, which indicate ethics commitment. The results revealed that two variables of Motivation and rewarding policy for ethical behavior and responding to unethical behavior (5 %) and Using ethical criteria in performance and efficiency evaluation of employees (10 %) have significant impact statistically. Though a positive correlation between Motivation and rewarding policy for ethical behavior and responding to unethical behavior and all nonfinancial business performance dimensions were shown, research confirmed that using ethical criteria in performance and efficiency evaluation of employees has a positive impact on Innovativeness and efficiency of business processes as well. The model explains 37,2777 % of the variability of the dependent variable Innovativeness and efficiency of business processes. Heteroscedasticity is not present (White's test LM = 62;2024; Breusch-Pagan LM = 5,95911), and that residuals are normally distributed (p -value = 0,566927). It could be concluded that

Table 2. Regression model with the dependent variable Client satisfaction.

| Code | Coefficient | Std. Error | t-ratio | p-value |
|--------------------|-------------|------------|---------|-------------|
| Const. | 2,25794 | 0,256823 | 8,7918 | <0,00001*** |
| BE_1 | 0,165324 | 0,0978315 | 1,6899 | 0,09451* |
| BE_2 | -0,0276695 | 0,127234 | -0,2175 | 0,82833 |
| BE_3 | 0,0141224 | 0,109232 | 0,1293 | 0,89742 |
| BE_4 | 0,015444 | 0,141952 | 0,1088 | 0,91361 |
| BE_5 | -0,196606 | 0,145599 | -1,3503 | 0,18030 |
| BE_6 | 0,172202 | 0,134153 | 1,2836 | 0,20257 |
| BE_7 | 0,00642077 | 0,104182 | 0,0616 | 0,95099 |
| BE_8 | 0,342048 | 0,135728 | 2,5201 | 0,01349** |
| BE_9 | -0,040798 | 0,122522 | -0,3330 | 0,73992 |
| Adjusted R-squared | | | | 0,262638 |

*statistically significant at 10 %

**statistically significant at 5 %

***statistically significant at 1 %

Table 3. Regression model with the dependent variable Human resources management.

| Code | Coefficient | Std. Error | t-ratio | p-value |
|--------------------|-------------|------------|---------|-------------|
| const | 2,00293 | 0,229402 | 8,7311 | <0,00001*** |
| BE_1 | 0,26669 | 0,0873858 | 3,0519 | 0,00299*** |
| BE_2 | 0,165291 | 0,113649 | 1,4544 | 0,14931 |
| BE_3 | -0,0775438 | 0,0975687 | -0,7948 | 0,42884 |
| BE_4 | -0,0627676 | 0,126796 | -0,4950 | 0,62179 |
| BE_5 | -0,104987 | 0,130053 | -0,8073 | 0,42164 |
| BE_6 | 0,146953 | 0,119829 | 1,2264 | 0,22327 |
| BE_7 | 0,0504204 | 0,0930583 | 0,5418 | 0,58928 |
| BE_8 | 0,0447339 | 0,121236 | 0,3690 | 0,71301 |
| BE_9 | 0,00592909 | 0,10944 | 0,0542 | 0,95691 |
| Adjusted R-squared | | | | 0,316860 |

*statistically significant at 1 %

Table 4. Regression model with the dependent variable Innovativeness and efficiency of business processes.

| | Coefficient | Std. Error | t-ratio | p-value |
|--------------------|-------------|------------|---------|-------------|
| const | 1,36935 | 0,287453 | 4,7637 | <0,00001*** |
| BE_1 | 0,237938 | 0,109499 | 2,1730 | 0,03241** |
| BE_2 | 0,0451613 | 0,142408 | 0,3171 | 0,75188 |
| BE_3 | -0,180842 | 0,122259 | -1,4792 | 0,14259 |
| BE_4 | 0,27172 | 0,158882 | 1,7102 | 0,09067* |
| BE_5 | -0,0284393 | 0,162964 | -0,1745 | 0,86185 |
| BE_6 | 0,0837863 | 0,150153 | 0,5580 | 0,57823 |
| BE_7 | -0,064877 | 0,116607 | -0,5564 | 0,57934 |
| BE_8 | 0,195979 | 0,151915 | 1,2901 | 0,20034 |
| BE_9 | 0,0417804 | 0,137135 | 0,3047 | 0,76132 |
| Adjusted R-squared | | | | 0,372777 |

*statistically significant at 10 %

**statistically significant at 5 %

***statistically significant at 1 %

there is a positive relationship between using ethical criteria in performance and efficiency evaluation of employees as a dimension of commitment to business ethics and innovativeness and efficiency of business processes as a nonfinancial business performance. Therefore, the third hypothesis is confirmed.

SUMMARY OF FINDINGS

A summary of our findings is presented in Table 5. For each of the independent variables the following information is provided: (i) if the independent variable does not have any significant impact it is stated as \emptyset ; (ii) if the independent variable does have significant impact on the dependent variable (+) or (-) signs are used to indicate the direction of the impact and 1 %, 5 % or 10 % are used in order to indicate the level of the significance.

Our research reveals that three of nine dimensions of commitment to business ethics have a significant impact on nonfinancial variables in Croatian companies. This may indicate that in an absence of legislation that additionally encourage companies to build ethical environment, Croatian companies do not implement all dimensions that represent a robust and sophisticated ethical program which is a standard on the regulated market. As a result, the companies in our sample could not recognize dimensions as important due to their absence. However, motivation and rewarding policy for ethical behavior and responding to unethical behavior, as a one of three positive dimensions of commitment to ethical business, is statistically significant in all three nonfinancial business performance variables. Our research confirms that it has a stronger positive impact on human resources management (significant at 1 %) compared to innovativeness plus efficiency of business processes (significant at 5 %) and client satisfaction (significant at 10 %).

Client satisfaction (customer satisfaction, market share, quality of products and services) is also investigated. Selecting suppliers based on the standards of ethics and compliance has a positive impact on client satisfaction which is in line with investigation conducted by other authors [3, 49]. Our research confirms that using ethical criteria in performance and efficiency evaluation of employees has a positive impact on innovativeness and efficiency of business processes as a dimension of nonfinancial business performance. This may indicate that the usage of the ethical criteria in performance and efficiency evaluation of employees could be a significant generator of the company innovativeness in Croatia. However, communicating ethical values within the company, promoting an ethical culture, having an unambiguous, visible commitment and involvement in solving ethical problems by senior management, using ethical criteria in risk assessment, implementing and integrating ethical criteria in organizational culture, using ethical criteria in corporate reporting to external stakeholders and conducting due diligence in terms of ethics and compliance in mergers and acquisitions, as dimensions of commitment to business ethics, do not have significant impact in any of the nonfinancial business performance, which contrary to the results of other authors [1, 2, 4].

In general, the findings suggest that ethically committed companies have to build an ethical culture based on measured dimensions. However, the results also suggest that not all dimensions of ethical commitment influence nonfinancial business performance. Moreover, based on our results we may also conclude that the overall level of company's ethical commitment matters when examining the particular dimensions of ethical commitment and nonfinancial business performance.

Table 5. Overview of the regression models. Note: +1 %, +5 %, and +10 % indicates positive statistical impact at 1 %, 5 % and 10 % of significance level; Ø indicates no statistical impact.

| Commitment to business ethics | | Dependent variables | | |
|-------------------------------|--|---------------------|----------------------------|---|
| Code | Dimensions | Client satisfaction | Human resources management | Innovativeness and efficiency of business processes |
| const | | +1% | +1% | +1% |
| BE_1 | Motivation and rewarding policy for ethical behavior and responding to unethical behavior | +10% | +1% | +5% |
| BE_2 | Communicating ethical values within the company | Ø | Ø | Ø |
| BE_3 | Promoting an ethical culture, having an unambiguous, visible commitment and involvement in solving ethical problems by senior management | Ø | Ø | Ø |
| BE_4 | Using ethical criteria in performance and efficiency evaluation of employees | Ø | Ø | +10% |
| BE_5 | Using ethical criteria in risk assessment | Ø | Ø | Ø |
| BE_6 | Implementing and integrating ethical criteria in organizational culture | Ø | Ø | Ø |
| BE_7 | Using ethical criteria in corporate reporting to external stakeholders | Ø | Ø | Ø |
| BE_8 | Selecting suppliers based on the standards of ethics and compliance | +5% | Ø | Ø |
| BE_9 | Conducting due diligence in terms of ethics and compliance in mergers and acquisitions | Ø | Ø | Ø |
| Adjusted R-squared | | 0,262638 | 0,316860 | 0,372777 |
| Hypothesis | | H1 confirmed | H2 confirmed | H3 confirmed |

CONCLUSIONS

Commitment to business ethics is an important tool for a company's long-term sustainable success that continually grows an academic and scholar interest. The prior studies on a commitment to business ethics mainly focus their attention on the financial and nonfinancial business performance instead of particular dimensions that promote commitment to business ethics and their impacts on separated nonfinancial business performances. To fill this important gap in the literature, we provide an empirical analysis concerning the relationship between commitment to business ethics and nonfinancial business performance. In doing so, we use nine dimensions to measure commitment to business ethics and three dimensions to measure nonfinancial business performance calculated as the average value of additional three variables. Additionally, to consider if the company's ethical commitment matters, we test our results in transition country, such as Croatia. We have chosen this country, due to an absence of legislation that additionally encourages companies to build ethical environment.

SUMMARY OF RESEARCH

This study tested the correlation between commitment to business ethics and objective of nonfinancial performance such as client satisfaction, human resources management plus innovativeness and efficiency of business processes, by using measures of aggregated employees' perceptions. The empirical results of the regression model show that certain dimension of commitment to business ethics had a positive influence on the nonfinancial performance of the companies. Moreover, authors found that motivation and rewarding policy for ethical behavior and responding to unethical behavior as a dimension of commitment to business ethics has distinctive effects on all three nonfinancial performance dimensions (client satisfaction, human resources management plus innovativeness and efficiency of business processes). The study confirmed that selecting suppliers based on the standards of ethics and compliance had a positive and strong influence on client satisfaction, considering the fact that client and customers' satisfaction continue to make the most important component for long-term performance success of the company, this present a significant issue. Authors confirmed the positive and significant influence of using ethical criteria in performance and efficiency evaluation of employees on innovativeness and efficiency of business processes as a dimension of a nonfinancial performance of the companies, as well.

PRACTICAL IMPLICATIONS

The results of the study raise the issue of some practical implications, and they are useful for business practitioners alike in a several way. First of all, this study proves that a certain dimension of commitment to business ethics increase nonfinancial performance through examining such relationship at the individual level. Secondly, this study provides practical implications for companies in developing countries such as Croatia by showing that commitment to business ethics can be an important predictor of nonfinancial performance as well as a client satisfaction, human resources management and innovativeness and efficiency of business processes. Thirdly, this paper confirmed that ethics and business go simultaneously in the modern economy. Our work provides evidence that doing the right thing is lastly the company's best interest. It represents that business ethics provides a greater degree of client and employees' satisfaction which in the long term result in loyalty for both categories and higher productivity regarding employees. Conclusively, this research, as a preliminary research can be a starting point for further research in other transition countries.

LIMITATIONS AND FUTURE STUDIES

The study has a certain limitation. Firstly, the data were collected in medium-sized and large companies; therefore small companies were excluded from the research. Thus, in future research, it would be useful to enlarge a sample with small sized companies and to enlarge the sample as a whole. Secondly, the data were present an individual perception of respondents; thus, they could be subjective. Thirdly, attitudes toward a commitment to business ethics and nonfinancial business performance present the views of one participant in each company. In the future studies, interviewing more participants would give a broader view of companies. Furthermore, the geographical focus of the research is an important limitation. Authors focused on companies in Croatia, but it would also be reasonable to investigate the links between commitment to business ethics and nonfinancial business performance in other transition countries and to compare the results with other more regulated markets. This study opens numerous future research areas mentioned above. Furthermore, the terms business ethics and corporate social responsibility (CSR) are often used interchangeably, but perceptions of the roles of each remain distinct [50]. CSR has become a popular topic for academic studies; producing many researches that provide

guidelines and measurement tools for an organization's social policy and explore the influence of these policies on companies and their stakeholders [51]. CSR has caught the growing attention of companies. Nowadays many of them participate in activities that address social, environmental and sustainability concerns as the issue of nonfinancial business performance. In the future research, it would be interesting to investigate the impact of ethical commitment to CSR, especially regarding the environment and community through company's philanthropic activities.

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MASSIVE OPEN ONLINE COURSES IN EDUCATION OF ROBOTICS

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ABSTRACT

Recently, the requirement for learning is constantly increasing. MOOC – massive open online courses represent educational revolution of the century. A MOOC is an online course accessible to unlimited number of participation and is an open access via the web. Mayor participants in the MOOCS are: Coursera, Udacity (Stanford, since 2012) and edX (Harvard, MIT, since 2012). In this paper two MOOCs are considered: Introduction for Robotics and Robotics Vision, both from the Queensland University of Technology, Brisbane, Australia.

KEY WORDS

MOOC, massive open online courses, robotics, Coursera, Udacity, edX

CLASSIFICATION

ACM: D.1.1.

JEL: O31

PACS: 89.70.Hj

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INTRODUCTION

Recently, the requirement for learning is constantly increasing. MOOC – massive open online courses represent educational revolution of the century. A MOOC is an online course accessible to unlimited number of participation and is an open access via the web.

Major participants in the MOOCs are:

- 1) Coursera, Stanford, since 2012, with 17 180 422 students, 1754 courses, 147 partners, [1],
- 2) Udacity, Stanford, since 2012, [2],
- 3) edX, Harvard, MIT, Berkeley, since 2012, [3].

The paper is organized as follows: In Section 1 is given the Introduction; in Section 2 the MOOC Introduction for Robotics is considered, Section 3 considers the MOOC Robotics Vision and in Section 4 is given conclusions of the paper.

INTRODUCTION TO ROBOTICS

This course [4] contains an introduction to the exciting world of robotics and the necessary mathematics and algorithms. You will develop an understanding of the representation of pose and motion, kinematics, dynamics and control [5-19] of robot. You will also be introduced to the variety of robots [20-25] and the diversity of tasks to which this knowledge and skills can be applied, the role of robots in society, but also associated ethical issues.

If you have access to a LEGO Mindstorms robotics development kit you will be able to build a simple robot arm and write the control software for it.

COURSE STRUCTURE

The course content will be released weekly.

- *Lecture 1:* Introduction to robotics,
- *Lecture 2:* Where things are in 2D,
- *Lecture 3:* Where things are in 3D,
- *Lecture 4:* Time varying coordinate frames,
- *Lecture 5:* Measuring the motion of things,
- *Lecture 6:* Robot arms and forward kinematics,
- *Lecture 7:* Inverse kinematics and robot motion,
- *Lecture 8:* Robot velocity in 2D,
- *Lecture 9:* Robot velocity in 3D,
- *Lecture 10:* Robot joint control,
- *Lecture 11:* Rigid body dynamics, and
- *Lecture 12:* Robots and the future.

This course combined with the Robotic Vision MOOC.

Course author is Prof. Peter Corke, Queensland University of Technology, Brisbane, Australia.

ROBOTIC VISION

Robotic vision introduces you to the field of computer vision and the corresponding mathematics and algorithms [26]. We would learn how to interpret images and how to determine the color, size, shape and position of objects in the space. It gives us a possibility to build an intelligent vision system that can recognise objects of different colors and shapes.

This course and the Introduction to robotics MOOC are based on a 13 weeks lasting undergraduate course Introduction to robotics. Course author is Prof. Peter Corke.

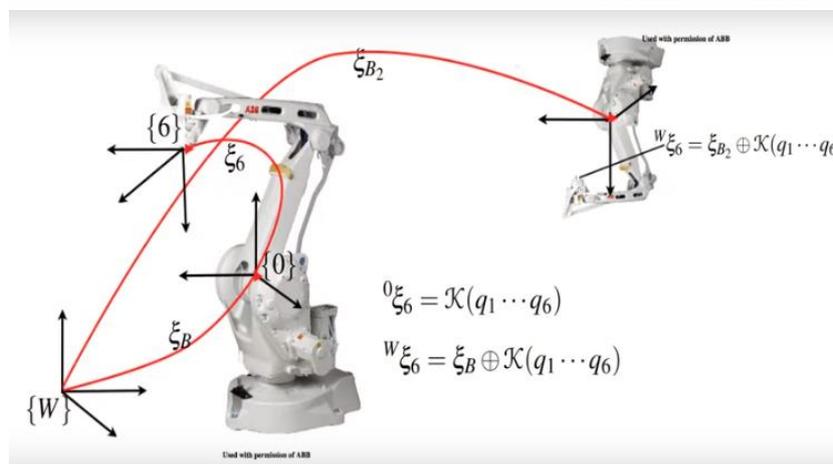


Figure 1. Excerpt from Introduction to Robotics.



Figure 2. MOOC Introduction to Robotics.



Figure 3. Robotic Vision.

By the end of this course you should be able to:

- describe and explain what robots are and what they can do,
- describe mathematically the position and orientation of objects and how they move,
- describe mathematically the relationship between robot joint coordinates and tool pose,
- reflect on the future role and development of robots in human society,
- compute the rigid-body forces in a robot and design a joint control system (optional advanced material),
- apply the mathematical, algorithmic and control principles of robot arm manipulators to implement a working robot through physical construction and software development (applies to optional project) [26, 27].

CONCLUSIONS

In this paper new trends – MOOC – in education of robotics are considered. MOOC – massive open online learning courses represent educational revolution of the century. A MOOC is an online course accessible to unlimited number of participants and is an open access via the web. Major participants in the MOOCs are: Coursera, Udacity (Stanford, since 2012) and edX (Harvard, MIT, since 2012). In this paper two MOOCs are considered: Introduction to Robotics and Robotics Vision, both from the Queensland University of Technology, Brisbane, Australia.

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NEW STANDARD ISO 9001:2015 AND ITS EFFECT ON ORGANISATIONS

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ABSTRACT

ISO 9001 is the international standard which specifies requirements for quality management systems (QMS). Organisations implement requirements of the standard to demonstrate the ability to consistently provide products and services that meet customer and regulatory requirements. It is the most popular standard of the ISO 9000 series and the only standard in the series to which organisations can certify.

The new version of ISO 9001 was released in September 2015 and changes made in ISO 9001:2015 are more significant than those produced during the 2008 revision. On first view are clearly seen changes in structure of ISO 9001:2015, where the number of sections expanded from 8 to 10 but this paper explain the main changes in understanding quality which include context of organisation, risk based thinking, knowledge as resource and leadership.

KEY WORDS

quality management system, context of organisation, risk based thinking, leadership, ISO 9001:2015

CLASSIFICATION

JEL: L15

INTRODUCTION

ISO 9001 was first published in 1987 by the International Organisation for Standardization (ISO), an international agency composed of the national standards bodies of more than 160 countries. The current version of ISO 9001:2015 was released in September 2015 [1].

Changes introduced in the 2015 revision are intended to ensure that ISO 9001 continues to adapt to the changing environments in which organisations operate. Some of the key updates in ISO 9001:2015 include the ‘context’ of the organisation, restructuring some of the information, an emphasis on risk-based thinking to enhance the application of the process approach, improved applicability for services, and increased leadership requirements, Table 1.

Changes in structure of ISO 9001:2015, expanding the number of sections from 8 to 10 with additions for performance management and evaluation which is said to help with future closer alignments among different standards through a new so called “Annex SL’ model” which provides a framework for drafting standards which can be applied concurrently (integrated management systems or multiple management systems) such as such as ISO 9001, ISO 14001, ISO 27001, or ISO 22301 [2].

Table 1. Comparison of sections in two versions of ISO 9001.

| Section | Current Standard Sections | Proposed Standard Sections |
|-------------|---------------------------------------|-----------------------------|
| Section 1: | Scope | Scope |
| Section 2: | Normative Reference | Normative References |
| Section 3: | Terms and Definitions | Terms and Definitions |
| Section 4: | General Requirements | Context of the Organisation |
| Section 5: | Management Responsibility | Leadership |
| Section 6: | Resource Management | Planning |
| Section 7: | Product Realization | Support |
| Section 8: | Measurement, Analysis and Improvement | Operation |
| Section 9: | – | Performance Evaluation |
| Section 10: | – | Improvement |

CONTEXT OF THE ORGANISATION

The “context” of the organisation (sometimes called its business or organisational environment) refers to the combination of internal and external factors that can be effect on organisation’s approach to its products, services and investments. As a result, implementation of an organisation’s QMS will be influenced by its context.

An organisation’s context can include, for example [6]:

- the specific objectives of the organisation,
- the needs and expectations of its customers and any other relevant ‘interested parties’ like state, regulatory agencies,
- the products and services,
- the complexity of both the processes that the organisation uses and the way in which they interact,
- size and organisational structure of the organisation.

This is not a completely new concept for Quality Management Systems, because Introduction of ISO 9001: 2008 (in section 0.1 General) can be found that the design and implementation of an organisation's Quality management system is influenced by [7]:

- i) its organisational environment, changes in that environment, and the risks associated with that environment,
- ii) its varying needs,
- iii) its particular objectives,
- iv) the products it provides,
- v) the processes it employs,
- vi) its size and organisational structure.

An organisation has to identify those external and internal factors (both positive and negative) which are relevant to its 'context' and that can affect its ability to achieve the intended outcome(s) of its management system.

The organisation must also continue to monitor and review those issues to establish whether any changes to them will affect its QMS, or its purpose.

Although many organisations will already be monitoring internal and external issues, this is a new requirement with which all clients will now need to comply.

There is no specific requirement that these internal and external issues, or their monitoring and review, have to be documented by an organisation, so auditors cannot simply ask for a list of issues or records of reviews.

However, in many cases this information could be available from several different sources. It may form part of an organisation's documented business plan or business strategy, for example, or be referenced on the organisation's website, in its annual reports, or can be one section in the Management Review.

However, there may be occasions where no such documentation is available. In such circumstances auditors cannot raise a finding unless they have clear evidence that an organisation has not identified particular internal or external issues that are relevant to its 'context'.

It may be that during an audit other QMS compliance problems are identified which are actually caused by the organisation's failure to identify such internal/external issues; in such a case the finding could be raised against clause 4.1 even though the actual problem was found, for example, in relation to the customer requirements for products and services.

It could be that auditors will be unable to reach a decision as to whether an organisation has identified those external and internal issues that are relevant to its 'context' until the end of the audit when they have reviewed all the other elements of the organisation's QMS. Only then, will they be able to identify whether there are any internal or external issues that the organisation has not identified.

Given the nature of the requirements relating to the 'context' of an organisation and the absence of any direct requirement for internal and external issues to be documented, there is likely to be occasions when a change in audit approach is required. Auditors approved for the organisations appropriate Technical Area will have knowledge of the general internal and external issues usually relevant to organisations operating in that business sector, but not necessarily any issues which are specific to the organisation.

Because of this reason, auditors may need to allow time before that audit to investigate their understanding of an organisation's own context; this may be through the organisation's website, or those of other which interact with the organisation. This is, in part, because the auditors must be in a position to challenge an organisation if they believe the organisation's has not satisfactorily considered all relevant internal and external issues.

Auditors are also now more likely to need to interview senior management in relation to the organisation's context. Since the organisation has to consider its 'strategic direction' when identifying internal and external issues, it is likely that discussion of these elements of an organisation's context will have to involve senior management.

Depending on an organisation's management structure, its Quality Manager (who is not obligatory in new version ISO 9001:2015), for example, may not have sufficient knowledge of the issues relevant to the organisation's context and be unable to provide the information necessary for the auditors to verify compliance with the requirements of this clause.

RISK BASED THINKING

ISO 9001:2015 incorporates term "Risk-based Thinking" in its requirements for the establishment, implementation, maintenance and continual improvement of the quality management system. This additional requirement in new version of standard is logical requirement in a way of achieve preventive management system.

In ISO 9000:2015, "Quality management systems – Fundamentals and vocabulary," risk is defined as the "effect of uncertainty." Notes in the definition further describe risk as a "deviation from the expected," either positive or negative. The term "uncertainty" is clarified as a lack of information or knowledge about an event that can be expressed in terms of consequences the likelihood of occurrence. Finally, ISO 9000:2015 states that risk is related to potential events, and that it's typically expressed as a result of the likelihood and consequence of such an event [3].

Let us consider risk as it is defined in ISO 14001:2015, "Environmental management systems," and in ISO 31000, "Risk management – Principles and guidelines." The definition of risk in ISO 14001:2015 is identical to ISO 9000:2015, even though it includes only four of the six notes from ISO 9000 [4]. However, the definition of risk in ISO 31000 is a little more specific than ISO 9001 and ISO 14001, and is defined as an "effect of uncertainty on objectives."

This is a good time to emphasize a few notions about risk. Risk in ISO 9001:2015 and ISO 14001:2015 is general, that is, it is a concept that can be applied anywhere in an organisation, including planning (Clause 6.0), i.e., the setting of objectives as it is defined in ISO 31000. Risk can be described as a potential event that can be expressed in terms of consequence, impact, or severity of the impact and its related likelihood of occurrence.

Risk appears in the normative parts of ISO 9001 eight times, and risk-based thinking appears once. Risk and risk-based thinking appear many times more when we study the informative portions of the standard, e.g., the introductory sections and the appendix.

Planning actions to address risks and opportunities can include: avoiding risk, eliminating the risk source, changing the likelihood or consequences (likelihood and impact), sharing the risk, retaining risk by informed decision and even taking risk in order to pursue an opportunity.

When planning actions to address risks, it is again imperative quality professionals must consider the context of their organisation. For example, the process of planning actions to mitigate a potential fault with a nuclear reactor at a power plant will be much more thorough and meticulous than planning actions to mitigate the risk of the wrong sandwiches being ordered for the staff vending machines.

Similar to this, the risk of an economic downturn in a country an organisation has little trade or links with is minor in comparison to a recession in the country it solely trades and operates. It is essential to understand your organisation and its strategic direction as this will enable you to determine and address its associated risks.

In easy way, to check the effectiveness of actions to address risk requires the organisation to ask, 'Does it work?'. There are various methods that organisation can check the effectiveness of actions to address risk, including:

- audits and internal reviews,
- KPI analysis, and
- project evaluations.

An important aspect of checking the effectiveness of actions to address risk is having the right data available to make informed decisions. By improving risk data aggregation capabilities, organisations can strengthen the capability and the status of the risk function to make judgments. This leads to gains in efficiency, reduced probability of losses, enhanced strategic decision-making and ultimately increased profitability.

Instant access to risk assessments, audit reports, customer complaints, non-conformance and document notification confirmations give management the ability to understand the organisation management system, carry out trend analysis and demonstrate control of 'culture of compliance'.

KNOWLEDGE LIKE A RESOURCE

In its 2015 revision, ISO 9001 is once again adapting to its times. Knowledge has become key element and crucial resource to successful projects and business development. The new standard considers knowledge like any other resource to be managed [3]:

- identify the knowledge necessary to carry out the activity in compliance with the QMS and to achieve the defined objectives,
- knowledge must be maintained, protected and made available where necessary, and
- anticipate changes in knowledge needs and manage the risk of failing to acquire knowledge in due time.

This is very important new requirement which help organisations in maintaining organisation knowledge and help all employers to perform every day operation on better way.

LEADERSHIP

ISO 9001:2015 places more emphasis on leadership and management commitment. It requires greater involvement by top managers and business leaders in controlling the quality management system [1].

On this way, ISO 9001:2015 is intended to encourage integration and harmonization with business processes and business strategies. The top management now has to take more responsibility for the effectiveness of the quality management system. In last version of ISO 9001:2008 this responsibility was addressed to Quality Manager.

Because ISO 9001:2015 pays more attention to risk management, interested parties and the context of the organisation, the quality management system also fits in better with the needs of the top management.

The quality management system is now more than ever a means for being strategically successful by addressing the needs of interested parties and by managing opportunities and threats. The 'management representative' of ISO 9001:2008 was a member of the management committee who had the responsibility and authority for steering the quality management system along the right lines. ISO 9001:2015 does not mention this aspect any more. The idea behind the change is that quality is a matter for everyone and for all levels within the organisation which is originally Japanese idea from their famous Total Quality Management.

The purpose of the standard is to take account of technological and societal changes. Information is no longer created, organised, managed, maintained, disseminated and accessed as it was 20 years ago when paper was the primary medium.

This change also allows for greater flexibility in companies' organisation. It is now possible to comply with the standard without jeopardizing managerial agility, as long as the fundamental principles are respected.

CONCLUSION

ISO 9001 standard has played great and perhaps the most important role in the perception of quality and understanding of the quality assurance and quality management in the last thirty years. Despite all attacks and objectively mistakes of these standards, it should be underline the great contribution of ISO 9000 to the World order of quality.

The new issue of ISO 9001:2015 was released in September 2015 and changes introduced in the 2015 revision are intended to ensure that ISO 9001 continues to adapt to the changing environments in which organisations operate and especially include the 'context' of the organisation, restructuring some of the information, risk-based thinking to enhance the application of the process approach, improved applicability for services, and increased leadership requirements [1].

ISO 9001:2015 expanding the number of sections from 8 to 10 and definitely better define the specific requirements which ISO 9001:2008 left incomplete.

Some requirements like Management review conduction in planed intervals or conduction of internal audits in planed intervals are still not strictly defined. It is left to organisation to define the period of conduction of management review or internal audit and my opinion is that those requirements certainly should be considered in the next revision [5].

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LEADERSHIP IN MIGRATION SYSTEMS: THE CASE OF ISRAEL

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ABSTRACT

The goal of this study is to depict the control processes in migration systems. In this article, a territorial migration system is understood to be a complex of migration streams related to a specific geographic region, embedded into a wider socio-economic system in its natural environment, and densely interacting with flows of information and matter passing through the area.

The research has been done by using qualitative methods for examining relevant information from special and fiction literature, mass media, and Internet sources. The theoretical framework of this article is based on a systemic approach to analyze social phenomena.

The analysis shows that a self-organized leadership system is responsible for running a large part of the control processes in a migration system. The leadership system in a migration system is a bricolage of diverse social apparatuses that perforce cooperate in the directing of the migrants' activities.

The bricolage form of leadership of a migration system is not the only possibility, but it is well suited to the unstable nature of migration systems, and therefore seemingly is the most plausible one. Leadership is the strongest shaping constituent in the Israeli migration system because it controls migration streams and ethnic and economic structures of the country, and so it must be extensively researched. The theoretical novelty of this study is in delineating of role and structure of the leadership system in the territorial migration system and of its impact on the wider social system.

KEY WORDS

leadership, migration system, complexity

CLASSIFICATION

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INTRODUCTION

The concept of a migration system still has no established definition, though the system approach has been accepted for decades in migration research [1]. The model of migration system comprised of a donor subsystem and a recipient subsystem interconnected by the migrant subsystem was argued to be the most suitable method for studying migrations as early as the beginning of the 1960s [2]. Mabogunje [3], in his frequently referred to paper on migration systems theory, defined migration system as a set of places linked by flows of people, goods, services, and information. In another widely mentioned book about migration systems [4], the Mabogunje's analysis of rural-urban migration within the African continent is extended to international migrations. International migration systems are viewed as consisting of countries that exchange migrants, and are also characterized by feedback mechanisms that connect the movement of people between particular countries, areas, and neighbourhoods to the related flows of goods, capital, knowledge, and information [5]. De Haas [6] denotes as migration system a migration stream that starts, grows, and demises. In this paper, a territorial migration system is understood to be a complex of migration streams related to a specific geographic region, embedded into a wider socio-economic system in its natural environment, and densely interacting with flows of information and matter passing through the area.

Migration systems play essential role in the function of societies. This role is shaped by specific characteristics of the migration systems. Migration systems are susceptible to changes; migration streams frequently are short-lived, so usually no firm formal apparatus of control can be built for this purpose. At times, existing formal management serves only the official goals of the host and/or sending countries, and migrants' needs are ignored or at least underestimated. In these cases, migrants take actions in order to achieve their ends, which can differ strongly from the formal ones. These activities are coordinated by means of migrant leadership. Leadership is widely studied in various spheres of social life, but not in migrations, in spite of the tremendous role of migrations in human societies and the essential place of leadership in migration processes. This paper questions the configuration and functions of leadership in the territorial migration system.

METHODS AND DATA

The study applies system analysis as a theoretical framework and qualitative research technique from Grounded theory: coding, constant comparing, and theoretical sampling [7]. Grounded theory has recently has been specially recommended for leadership research [8, 9]. Texts from various sources – special and fiction literature, internet sites, blogs, newspapers, and so on, were used in the analysis. They were selected for their relevance to the research issues. The procedure of applying of the Grounded theory techniques is not presented in the paper, only the results.

MIGRATION SYSTEM OF ISRAEL

The migration system of Israel includes Jewish and non-Jewish migration streams to, from, and within Israel, and among them are the flows of Aliyah (Jewish immigration to Israel), regular and irregular foreign workers, Palestinians, and other less noticeable migration movements, such as tourists who stay in Israel after their visas expire. Migration systems are constantly changing – some streams fade and disappear, some emerge; long-existing streams vary in their components and attributes. However, behind these unceasing changes is a stable core structure of migration streams determined by long-term socioeconomic, and environmental settings. Changing migration streams in one system commonly are similar; for example, in Israel, a Jewish immigration stream from one country is replaced by a flow from another country. To analyse the social impact of the migration system, some mechanisms of its functioning are

considered. Social mechanisms are arrangements of entities and activities that commonly produce a certain type of outcome [10]. Some opinions state that the analysis of social mechanisms is of key significance for advancement in sociological research [11], others contest the use of mechanism-based explanations [12]. It is also said that analysis of social mechanisms is able to help to clarify social phenomena, but not predict them [13]. Hence, the possible impact of the migration system should be seen as plausible and not as expected or predicted.

Mechanisms of migration systems encompass social arrangements of various natures. Administrative management of migration belongs to the mechanisms of the migration system. The Ministry of Immigrant Absorption is such a mechanism that cares for new immigrants and returned Israelis. The Jewish Agency is a special mechanism in the Israeli migration system that is responsible for the Jewish immigration to Israel, but only for bringing them into Israel – not for their integration. It is also the principal organization entitled to allocate lands for settlement [14], and so influencing internal migrations. The Population, Immigration, and Border Authority, formerly the Israeli immigration police, is an additional mechanism of the migration system. It confronts illegal, irregular, and undocumented immigration to Israel. Administrative management of migration includes laws and criteria that regulate the entrance of foreigners into Israel. These are imposed by the state. However, immigration criteria are used also by voluntary organizations for regulation of the numbers and characteristics of the immigrants. For example, the vice president of *Nefesh B'Nefesh*, the voluntary organization that facilitates immigration to Israel from North America, justifies their selection criteria for the Jewish immigrants the organization brings to Israel. He said, “We have two basic criteria: We accept candidates who visited Israel prior to their migration, and if they did not we arrange such a visit for them, and we do not accept candidates with problems, such as debts, mental problems. These conditions are important for the success of the integration process... We want to encourage a quality immigration that will be satisfied, and in this way will encourage others to come.” [15].

The migration system mechanisms include also physical constructions intended to regulate movements of people. The Israel-built “separation wall” between Israeli and Palestinian territories was not started as a reaction to unwanted migration, but in response to suicide bombings and other terrorist Palestinian actions. Nevertheless, it serves as a mechanism of migration control, especially, of illegal Palestinian commuting. The wall also delimits the migration of Israeli settlers, most of whom are prone to living within the separation lines. In addition, it demarcates a supposed future border between the two countries in the future and thus defines the current migration streams by determining the actual settlement options for the two peoples. The wall and the guard on the Egypt border initially were planned to serve as a mechanism in the migration system. In 2010, Israel began building a barrier along its border with Egypt to prevent the influx of illegals from African countries. Its effectiveness determines the number of infiltrators. Construction was completed in January 2013. Two hundred and thirty kilometres of fence has been built [16]. While 9 570 citizens from various African countries entered Israel via the Egyptian border in the first half of 2012, only thirty-four did the same in the first six months of 2013 after construction of the barrier was completed. It represents a decrease of over 99 % [17].

Similar to the international migration system [18], the migration system of Israel lacks overall governance and elaborated migration policy [19]. The Israeli migration system is, to some degree, controlled by the state in accordance with current migration regulations, but it cannot be fully regulated by its governmental structures. The state may close borders and impose restrictions on the work and residences of the migrants. It may influence ideology in the field of migration by diffusion of desired ideals. The state may establish a special police force to treat with the migrants and use other formal structures to control them. In international

streams, the origin and channels of migration systems cannot be fully controlled. Due to the democratic nature of Israeli society, effective control of the immigrants also is complicated. Internal migration may be influenced but not fully managed even in totalitarian states, and even less so in democratic ones. At times, existing formal management serves only the official goals of the host and/or sending countries, and migrants' needs are more or less ignored. Processes leading to unstable or uncertain situations create both the need and the setting for leadership [20]. In the absence of a strong, general authority managing migration, the autonomous state, market, voluntary, and other groups, as well as individuals, decide their own migration strategies. Migrants and residents of the sending and receiving areas self-organize in order to achieve their own sometimes-conflicting ends. Haken [21; p.11] defines self-organization in the following way: "A system is self-organizing if it acquires a spatial, temporal, or functional structure without specific interference from the outside." Self-managing systems are able to adapt themselves in larger, self-organizing systems [22], therefore, a migration system with relatively independent leadership can quite autonomously adapt in its hosting society. A leadership system fosters the forming of regulating forces in the migration system and shapes their development.

LEADERSHIP IN THE MIGRATION SYSTEM OF ISRAEL

CONCEPT OF LEADERSHIP

Leadership is a complex concept, a definition for which still is not settled [23]. Leadership is embedded in interactions and social relations, and associated with the achievement of some goals by the social group through the appropriate organization of that group [24]. Leadership exists in any social species [25]. In biology, the term leadership relates to the arrangement of type, planning, and length of a common action [26]. Leadership can be broadly described as a process of influence on group activities in the setting and attaining of mutual goals [25, 27]. According to the Complexity Leadership Theory [28-30], leadership is a social process from which a collective motivation for action emerges. Leadership provides to collectivity purpose, meaning, and strategies by setting a common vision [31]. Leadership is a process by which new targets, routes, ideas, values, attitudes, and conducts are set. Sources of leadership can be an individual, collective, and/or the public settings from which people are influenced [32]. The majority of existing definitions of leadership include the ability to influence [33], and therefore leadership research needs to study the nature of social influence processes [8]. To analyse leadership, its roles, forms, and mechanisms must be analysed. Leadership roles embrace what leadership does; leadership forms are related to organization structures of leadership, and leadership mechanisms are ways through which leadership does it.

Roles are behavioural patterns-arrays of linked activities performed in a concrete social situation [34]. Commonly, the role is attributed to human actor(s); however, it can be attributed to a social phenomenon that carries out a specific function in social life, as well. Leadership roles embrace providing vision, organizing, inspiring, problem solving, and decision-making. Roles of leadership in modern migration systems are commonly limited to the launching of decision-making processes, and less to making the decisions. Leadership must be distinguished from management. Leadership in migration offers general ideas about when and where to move; management provides tools for their realization. Leadership is providing solutions in crises – management is supplying solutions in routine processes. It also may be said: leaders provide vision; managers provide execution [35-37]. Crisis may be chronic and continuous if the process is neglected by management structures. Management derives its authority from the recognized source of power; leadership is always self-appointed. Leadership is less concerned with the implementation of the generated plans

and strategies. The implementation is done through realization of the decisions made earlier by management; some of the decisions include establishment of organizations that are able to carry out the decisions. Leadership influences actions; management forces peoples to act in a definite manner. Management need formal apparatus to be implemented; leadership may be exercised in a much more informal mode.

Structurally, leadership practices can be categorized as either focused or distributed [38, 39]. Focused leadership implies following a specific figure for leadership's implementation; distributed leadership is multifocal or dispersed. Distributed leadership shares common ideas, which have some dissimilarities but one common basis. Other types of leadership can be related to these two. Shared leadership is "a dynamic, interactive influence process among individuals in groups for which the objective is to lead one another to the achievement of group or organizational goals or both" [40; p.1]. Relational leadership views leadership as a social arrangement that is grown from contacts between groups and their members in the context of their relationships [41]. Adaptive leadership induces interacting agents to generate adaptive modifications [42]. Integrative leadership is one that brings diverse individuals and collectivises together to realize common goals [43]. Factually, all these types are different facets of the focused or distributed leaderships, and similar to opinion, servant, charismatic, and other leadership types emphasize various aspects of the phenomena. Various forms and styles of leadership are observed in different social situations in which specific aspects of leadership became more salient.

Leadership mechanisms are the social procedures through which leadership is accomplished. Mechanisms of leadership are fully categorized as leadership factors comprising the full range leadership theory – some of them are transformational (inspirational motivation, idealized influence, intellectual stimulation, individualized consideration), some are transactional (contingent reward, active management-by-exception, passive management-by-exception), and one is a laissez-faire leadership factor [44, 45]. Mechanisms that are more specific can be related to the listed in the full-range leadership theory. Mechanisms of leadership can be operated by personified leaders, organizations, personal networks, and by interactions of various system elements. Some of the mechanisms and components of the leadership in the Israeli migration system are scrutinized below.

COMPONENTS OF ISRAELI MIGRANT LEADERSHIP

Up to now, no steady personified leaders have appeared in the Israeli migration system. Temporary, local, self-organized or heteronomous leadership, such as leadership of spontaneous demonstrations of protest or of illegal immigrants' organizations, is very volatile and has not produced discernible long-term leaders yet. At times, some influencing persons can be identified. On 7 June 1995, a new immigrant party was announced; the new political movement was given the name *Yisrael Ba'aliya*, which means "Israel in Aliyah" (Aliyah in Hebrew Jewish immigration to Israel) and "Israel on the rise" in English. The party heads worked hard to cast off its image as a "Russian" party and emphasized the fact that there was a Canadian immigrant on the sixth place of the party's candidates list and an Argentinean on the tenth. At the election, Israel in Aliyah captured seven seats in the Knesset. Quite soon, however, the voting for Israel in Aliyah significantly decreased. From the seven mandates that Israel in Aliyah won in the 1996 Knesset elections, it dropped down to six in 1999, and finally in 2003 to only two. Immediately after the 2003 elections, Israel in Aliyah decided to stop being a political party and joined the Likud, the large Israeli party. Natan Sharansky, head of the party, explained the fading of Israel in Aliyah as successful integration of the immigrants in Israeli society after ten years in the country, which makes an immigrant party unnecessary [46]. It seems plausible that during the last few decades, the migration leadership system in Israel had no need for personified leaders, especially long-term ones, because other means ran its mechanisms.

Migration organizations are another important part of migration leadership. Immigrant groups or organizations usually serve specific sectors of the system. Some migrant organizations are more stable than others are. Migrant organizations' effect on the migration leadership system is a combined result of the activities of all of them. In chaotic environments, organizations may create some order [47]. The role of governmental authorities, such as the Ministry of Immigrant Absorption, and of public organizations, like The Jewish Agency, seems to be managerial rather than leading. The short list below aims to show the diversity of the Israel migrant organizations, and immigrant and anti-immigrant as well. These organizations can be classified as:

- Aliyah organizations – organizations of immigrants who came to Israel in the streams of the Jewish immigration,
- Non-Aliyah organizations of regular and irregular immigrants (the number of these immigrants has been growing in the last few decades),
- Corresponding organizations of the receiving population, including both those supporting and opposing specific migration streams.

Some of the following organizations are named in order to demonstrate their diversity:

- The Association of Americans and Canadians in Israel (AACI) is a non-profit, voluntary organization of American and Canadian Jews who have immigrated to Israel,
- Nefesh B'Nefesh is an organization that encourages and helps Jewish people from North America and the United Kingdom to immigrate to Israel,
- The Soviet Jewry Zionist Forum served as an umbrella organization for some 40 volunteer and professional organizations of newcomers, offering counselling services, legal and civil rights protection services, and cultural and library activities,
- Kav LaOved (Worker's Hotline) is a non-profit, non-governmental organization committed to protecting the rights of disadvantaged workers employed in Israel and by Israelis in the West Bank, including Palestinians, migrant workers, subcontracted workers and new immigrants,
- Adalah ("Justice" in Arabic) – The Legal Center for Arab Minority Rights in Israel is an independent human rights organization and legal center. Established in November 1996, it works to promote and defend the rights of Palestinian Arabs. Adalah seeks to achieve equal individual and collective rights for Palestinian Arabs. Adalah challenges the 2003 Citizenship Law, which bans family unification between Palestinian citizens of Israel and their Palestinian spouses from the Judea and Samaria Area,
- ASSAF (Aid Organization for Refugees and Asylum Seekers in Israel) was founded in 2007 in order to aid refugees and asylum seekers in Israel,
- The Legal Forum for Israel was founded in 2004 in order to protect the rights of residents of Gush Katif and northern Samaria in the wake of the Disengagement, the withdrawal of the Jewish residents from the Gaza strip. The Forum takes care of the illegal construction – subject directly related to migration – among other migration-related activities such as protests against infiltrators,
- Sikkuy beMisgav ("A Chance in Misgav" in Hebrew) was established in year 2000 and its principal action has been to combat spatial discrimination in areas where the government applies anti-Arab demographic policies,
- Amana, the settlement movement of Gush Emunim, was established in 1978 with the primary goal of developing communities in Judea, Samaria, The Golan Heights, The Galilee, The Negev, and Gush Katif. This goal includes not only the establishment of communities and their supportive industries and social services, but also their maintenance and advancement,
- Filipino workers who have stable presence in Israel built a very developed structure of ethnic voluntary organizations of various profiles,

- other immigrant groups, mostly irregular migrants, organize churches, kindergartens, places of entertainment, and immigrant organizations, but they usually are short-lived because they are not tolerated by Israeli authorities [48].

All of the aforementioned actors, as well as many others, function within different segments of the Israeli migration system, and none of them play a decisive role even in its specific domain or in the migration system as a whole. This is an example of when it is not simple to discern the presence of leadership in a social system. Usually, processes of leadership are imperceptible; some of them can be grasped as leadership, as well as not leadership, depending on the spectator's understanding of leadership [20]. Everyone has an implicit concept of leadership, containing appropriate behaviour, traits, and expected results. Leadership is strongly associated with status, so the two are frequently confused [49]. High-rank managers are often automatically taken for leaders, and managerial behaviour for leadership. Frequently, non-professionals as well as researchers look for outstanding persons as leaders, and thus they deny existence of leadership in various settings and particularly in migrations. Embodied leadership must be recognized by members of society, otherwise the leader(s) cannot function as such; non-embodied leadership does not need social recognition and frequently it is unnoticed even by researchers.

Since many diverse factors lead the Israeli migration system, the leadership is dispersed, and the question of detecting and analysing its configuration requires a proper approach. The complexity view of leadership seems to be the most appropriate for understanding the leadership in migration systems. A complexity view of leadership suggests that leadership is not focused in a person, but rather in a social dynamic [42, 50]. "Much of leadership thinking has failed to recognize that leadership is not merely the influential act of an individual or individuals but rather is embedded in a complex interplay of numerous interacting forces." [28; p.302]. Complex adaptive system is entity consisting of many interrelated-linked by numerous interconnections-agents, which behave as a united whole [28]. "Agents" means relatively independent entities that can interact with other entities and change their behaviour because of those interactions. Agents can include, for example, traits, individuals, procedures or routines, decision-making units, systems, firms, and so on. Leadership takes place when the behaviour of a number of agents is influenced by interaction(s) with other agents [51].

Similarly, the network approach [52] locates leadership not in the attributes of individuals, but in the relationships connecting individuals. Yukl gives a definition of leadership that does not include leaders: "Leadership is the process of influencing others to understand and agree about what needs to be done and how to do it, and the process of facilitating individual and collective efforts to accomplish shared objectives" [53; p.8]. This approach does not nullify individual leaders, but focuses on the role of systemic activities [54].

The complexity vision has something in common with the philosophy of Leo Tolstoy: "Only by admitting an infinitesimal unit for observation – a differential of history, that is, the uniform strivings of people – and attaining to the art of integrating them (taking the sums of these infinitesimal quantities) can we hope to comprehend the laws of history" [55; p.608]. The functions of leadership are distributed between various agents, wherein no one is a leader, but altogether they produce leadership in the migration system.

LEADERSHIP SYSTEM

When emphasis in leadership research is moved from leaders to leadership, the systemic view of leadership and the study of leadership as a system becomes more important. Instead of speaking about a leader, it is better to speak about leadership systems. A leadership system is built of organizational arrangements and processes through which leadership is exercised [56].

A leadership system must be complex enough to lead a compound system; it is analogous to Ashby's Law of Requisite Variety [57]. The outcome of this principle is the inability of an individual leader to lead in some complex situations. Migration systems are very complex, and a variety of agents carry out leadership in migrations: outstanding persons, when they exist, formal organizations, informal groups, personal networks, and decision-making made by collective intelligence. No one of these components is obligatory for the functioning of the leadership system, but at least some of them must exist in order to realize the leadership.

Different mechanisms work in embodied and non-embodied leadership. In leadership without leader(s), mechanisms are employed that perform the roles of embodied leaders. In the absence of embodied leaders in the migration system, the pivotal role in the operation of the migration leadership system belongs to "an invisible hand" [58] of collective intelligence. Non-embodied leadership is carried out by means of collective intelligence. This is compliant with the complexity view of leadership. Collective intelligence emerges from the collective collaborative and competitive activities of many actors, and results in mutual decision-making. Collective intelligence cannot be traced simply to individuals, but rather to the interactions between persons, groups, organizations, etc. The collective intelligence is comprised of all means and rules that are used in order to make and realize decisions. Mechanisms of collective intelligence are institutions, such as professional teams, focused meetings, purposeful communities like Wikipedia, majority rule, information markets, or the underlying algorithms of Google [59]. Mechanisms of collective intelligence embrace mass media, personal and virtual networks of persons, groups, organizations, and so on. They also include local leaders and managers, opinion and serving leaders of networks, and managers of meeting points (such as groceries and eateries), and grassroots.

One mechanism of collective intelligence is collective sense-making, in which people construe social reality [60]. Sense-making has a principal role in intellectual changes [61]. Holmberg and Tyrstrup [62] proposed to examine sense-making processes, the processes by which individuals and groups develop shared understanding (making sense) of their situation, to understand leadership. Sense-making is considered to be a key constituent of distributed leadership [63]. An additional mechanism of collective intelligence is stigmergy. This self-organization process was first detected in insect societies. It describes situations in which leaving meaningful marks in certain location influences others and induces them to choose that path [59]. With stigmergy in human collectives, the task is driven by the idea, not by a person or group of persons. For example, in online bookstores, the function "People who bought this book also bought these other books" stimulates people to purchase definite books. These books may be freely chosen by customers or recommended by anonymous advertisers. Pieces of information about streams in migration systems are left everywhere – in press, on the Internet, in individual memories, and through rumours; they are effectively transferred to people and influence their behaviour.

Mechanisms of collective intelligence produce ideological effects. They are ideological because of the venue where they work and the outcomes they may have [64]. Use of ideology is a widely employed mechanism of migration systems. Every political slogan has its migration significances and therefore belongs to the leadership component of the migration system of Israel.

The central idea in the Israeli political consensus includes the following principles: a Democratic Jewish state, free market, peace process, and nonviolent inclusion in the region. The Arab-Israeli peace processes of the middle 1990s overlapped with the liberalization of Israel's economy; it coincided with a period of neo-liberal economic transformation [65]. Neoliberalism – the ideology stating that the market is able to guide all human actions – has become prevalent since around the 1970s [66]. Neoliberal attitudes have produced substantial

political effects for managing migration. From the point of view of market rationality, migrants are treated as a flexible and replaceable commodity. The task of migrants' integration is principally left to market forces. Marketization, an additional ideological principle that is at play in Israel, accepts the inflow of highly skilled migrants as positive for the economy, while considering refugees and asylum seekers as non-worthy [67]. Similarly, the "two states for two peoples" principle entails consequences for migration streams. It defines possible directions for Jewish and Arab migration streams in the West Bank/Israel, preventing migration of the Jews to the West Bank and the Arabs to Israel. The one-state solution is also about migration streams in the West Bank/Israel. The one-state solution is supported by people of various political backgrounds [68-72], but they prioritize cardinally different migration streams to be supported; some require Jewish in stream to be restricted and the Arab one encouraged, while the others demand just the opposite.

Ideas in leadership systems are produced and disseminated using various social mechanisms. Leadership is responsible for the production and implementation of ideology, and is directed by ideology. Public sociology as a construction of a scientific foundation of popular ideology is such mechanism of leadership in modern knowledge society. Ideology is a part of a worldview that is directly used in organized social action. Ideas produced in public sociology can influence public and popular opinions [73]. Public sociology is an important mechanism in the Israeli migration system. Israeli sociology tries to influence migration streams in the Israeli migration system. An example of public sociology can be illustrated by the work of the Israeli demographer Arnon Sofer. He claimed that from a security perspective, the African irregular immigrants might serve as "informants" of terrorist organizations; from the demographic point of view, they contribute to congestion in cities and to a rise in crime, and, generally, illegal immigrants can become a demographic threat to the Jewish majority [74].

Generally, use of texts and language is a widely applied leadership mechanism. Texts have longer-term causal effects on identities, beliefs, attitudes, values, and so on [75]. A new reality must undergo sense-making – new popular terminology that is able to cope with reality is continually developed. Uses and diffusion of texts and terms are grounded on different techniques, from diffusion through gossip to publications in newspapers and scientific publications. Collective intelligence paves the way from ideas to ideologies by assigning specific meanings for terms used in popular terminology. Word choice also has influential consequences [76]. Insertion of specific terms into popular terminology is a mechanism of social control. Popular terminology is a public vocabulary of these terms. "By renaming migrants 'infiltrators,' Israel is forging a new reality. As they manipulate terminology, Israeli politicians can paint migrants as a menace – not unlike Palestinian refugees." [77]. The opposite can be also claimed – by calling infiltrators 'migrants', the author tries to create a new reality and affect the migration stream by altering the attitude of the receiving population to the incomers.

Consensus-building is the essential leadership mechanism. It is increasingly applied for dealing with social and political disintegration [78]. Consensus is always a result of collective intelligence, even if the idea was imposed by authorities and to be accepted must undergo mutual valuation. Consensus is a self-organized way of social co-existence. Consensus-building has emerged as the most acceptable way of solving social problems because of its technological possibilities in a highly networked society [78]. Constructing and using social tags is a mechanism of leadership. A social tag is any structure or a piece of information that facilitates social activities. A tag can be a new technology, social leader, an idea, a symbol, or a belief [79, 80]. As a reward for playing this role, tag leaders are recognized by social structures and can succeed, for example, in local and country elections.

Construction of collective (social) and individual identities is also a leadership mechanism. The ability of leadership to lead depends on the existence of social identities and, more specifically, shared identities [81]. A leadership system defines belonging and implementation of the principles of the belonging to the emerging ethnic entity. “Melting pot” and “salad bowl” are immigration ideologies; both with definite ethnic goals. When the ethnicity of the immigrants is compatible with the consensual definition of the ethnicity, the immigration policy is a melting-pot type that is, a complete intermingling of the immigrants and hosting population; otherwise, it is a salad-bowl kind, which means no mixing between the ethnic and cultural groups. The process of ethnic identity formation is in understanding the expression and preservation of boundaries between groups [82]. Ethnicity is commonly considered to be a social construct [83]. Strong ethnic identity is able to restrict coming of undesired racial or ethnic groups, even if there exists a great demand for labour force. This ethnic position was made possible through the building of a wall against infiltrators on the Egyptian border. In Israel, irregular immigrants are welcomed not by people living in deprived neighbourhoods where the infiltrators settled, but by the wealthy population in the living quarters where the infiltrators illegally work. Generally, elites tend to welcome immigrants and foreign culture much more than the mass of the population [84]. In the public mind, infiltrators are perpetrators. Local, low-skilled workers lose to unskilled immigration even if they do not compete with immigrants in the labour market [85]. Since the late 1990s, a departure from multiculturalism in integration policy and a reverse towards civic integration has been detected all over Europe [86]. Nicolas Sarkozy, the former French President, said, “In all our democracies, too much attention has been paid to the identity of those who arrived and not enough to the identity of the host country,” cited in [87].

Change of attitudes towards non-consensual migration streams is a mechanism of migration leadership systems. Some migration streams are still lacking consensus in Israel - among them Jewish emigration from Israel, Jewish migration to Judea and Samaria, Arab immigration to Israel, and irregular immigration from Africa to Israel, though attitudes to these migrations are undergoing constant changes. Constructing new attitudes towards Jewish emigration is a leadership mechanism catalysing out streams of migrants from Israel. In the 1980s in Israel, Jewish emigration was still considered to be a negative phenomenon, though gaining some popular legitimacy [88]. In the 2010s, it seems to be becoming much more acceptable [89]. A strong stigmergy-like effect can be seen in the social contagion influence on emigration in the decisions of others to also leave Israel [88].

BRICOLAGE LEADERSHIP

Migration systems are controlled in various degrees by four sectors of society: the government-public sector, the market sector, the non-profit sector, and the criminal sector (for example, by human traffickers or illegal employers) [90, 91]. In addition, numerous factors in the public arena take the initiative – individuals, organizations, courts, manpower companies, Knesset (Israeli parliament) members, religious and community activists, collective intelligence, and various other agents. As complexity view states leadership can be accomplished through any communications that are distributed through the social system [42, 79]. They use different leadership mechanisms and the interplay of all those produces leadership and actual outcomes in the society. The resulting form of leadership in the migration system is a distributed bricolage leadership.

“Bricolage” means construction from a diverse range of materials or sources at hand. It is the improvised adaptation of existing objects to new aims [92]. Bricolage depends on the inner potentials of the available materials [93]. A bricolage leadership system consists of a number of mutually interdependent diverse leaderships acting in one social system. The role of bricolage

leadership in non-profit organizations is recognized by grass root leaders [94]. Bricolage can act as a mechanism for institutional change [95]; however, researchers frequently overlook the concept of bricolage [96]. The distributed bricolage leadership can be seen as shared leadership; however, the shared leadership is not always only voluntary and benevolent division of leadership functions, it can include also rival competing leadership. Collaborating, conflicting, and interlocked co-leaderships mix into one common leadership; the result of their activity defines the path of the migration system. This process is not peculiar of migration leadership systems, but it is salient in such systems because of their transient nature. In migration systems, not only bricolage leadership but also bricolage ideologies emerge.

The state of Israel is faced with a turbulent environment weakened by much conflicting interests, where each group admits that it cannot get rid of either its partners or opponents, but has to live and compromise with them to survive. Migrants share some common views and beliefs that enable their coexistence. The limits of internal struggles of constituent components of the leadership system are nebulously defined, but commonly accepted, and the vast majority of the agents accept these vaguely defined final goals. Setting of unachievable or hardly attainable political goals, such as attaining peace, gives to existing social arrangements a framework for enduring existence. It keeps the social system in the status quo, which is ideologically acceptable for nobody but comfortable enough for everybody, and thus supports the bricolage form of leadership. The contradicting ideological views create and are created by opposing leaderships and support diverse migration streams in Israel. The immigrants import some of the ingredients of the migration ideology; these may be a formal religion, popular beliefs, social doctrines, and so on. In a migration system, they cannot be amalgamated into one integral system due to the transitory nature of a migration system. The leadership system of the migration system is a subsystem of the wider leadership system of the host society and is strongly influenced by it. Configurations of the leadership system and of the whole society are closely related. The bricolage character of the leadership in the migration system has a strong impact on the Israeli society. It imparts to the Israeli society, primarily to its ethnic composition, a similar bricolage character.

FUTURE CONSIDERATIONS

The bricolage form of leadership of a migration system is not the only possibility, but it is well suited to the unstable nature of such systems, and therefore seemingly is the most plausible one. Bricolage leadership systems now act in many social systems, from social protest movements to “spontaneous” individual terroristic acts, which are induced by dispersed leadership. In the past, decision-making at times of crisis demanded focused leaders – people who could create a mechanism of gathering of information, processing and disseminating decisions, and monitoring their implementation. Modern technologies make it possible to have decision-making based on collective intelligence and managing of successful collective actions without the building of a personified apparatus. Use of modern technologies plays a major role in the organization of mutual social actions [97], so organizational techniques like using the Internet and mobile telephone communications may be seen as prevailing mechanisms of leadership. The role of collective intelligence in modern societies’ governance is strengthening continuously. Embodied leadership in modern societies is shrinking. The Knowledge Era calls for a new leadership paradigm [28] and transition from focusing on leader(s) to focusing on leadership is such a paradigm shift [98] in the leadership sciences. However, organized, governmental, and/or other agencies can take control of these self-organized bricolage leadership systems and the democratic stage of self-organized leadership will ceased to exist. Plato already forewarned in 360 B.C., “... tyranny naturally arises out of democracy” [99]. As we might expect, it is very plausible

that control and command mechanisms will be developed within the modern virtual space, and in the future social self-organization will be impossible, or at least very restricted. Leadership is evolving with the times and social development [100]. The informational age replaced the industrial age, and new socioeconomic conditions include free markets and freedom of speech and movements. These new social conditions require new leadership forms and new leadership mechanisms to perform new and old leadership roles.

Leadership is the strongest shaping constituent in the Israeli migration system because it controls migration streams and ethnic and economic structures of the country, and so it must be extensively researched. The study of leadership in migrations can also facilitate leadership research in other domains of human activity where this aspect was not considered yet. This paper starts exploring leadership in migration systems, which was insufficiently studied previously. There are some social domains where the role of leadership is still overlooked, and this should be changed. The role of leadership in shaping other demographic phenomena – fertility and mortality was also not studied yet, and should be studied in close connection with migration systems. The scope of this study may be widened to the leadership systems of society as a whole, and of its other subsystems in particular. “Leadership can explain the otherwise unexplainable” [79; p.390].

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THE ELUSIVENESS OF LEARNER-CENTRED TEACHING

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ABSTRACT

This research will explore teaching styles of university professors. Teaching style is an umbrella term for teaching decisions made during the entire teaching process – planning, delivery, and evaluation. Contemporary university teachers are advised to adopt the learner-centred teaching style which is assumed to produce remarkable possibilities. In the Fall Semester 2015 fifty-two respondents in different faculties of International University of Sarajevo were surveyed using The Principles of Adult Learning Scale inventory designed by Gary J. Conti. Inventory scores were calculated according to guidelines suggested by the author of the inventory. The scores revealed that majority of respondents strongly supported teacher-centred rather than learner-centred styles of instruction. Scores were analysed on gender lines and across three different faculties, namely: Arts and Social Sciences; Business and Administration; Engineering and Natural Sciences. In all five groups none of the seven teaching style indicators was found to conform with the learner-centred teaching criteria. There was no statistically significant difference between the two genders' preference for a teaching style. And there was no statistically significant difference between teaching style preference across the three different faculties. The results of this research imply that the learner-centred style of instruction is not frequently implemented. Secondly, the results indicate that the requirements necessary for proper application of the learner-centred teaching style are not easy to meet in current written and unwritten norms. Finally, the results show that traditional teaching styles, which have been preserved in different scientific fields, still predominate in universities.

KEY WORDS

teaching styles, learner-centred, higher education, PALS

CLASSIFICATION

JEL: I23

INTRODUCTION

High Level Group for the Modernisation of Higher Education, which was invited by the 2010-2014 European Commissioner for Education, Culture, Multilingualism and Youth “to set out recommendations on enhancing higher education” [1], recommends the adoption of the learner-centred instruction model. They also recommend in-service teacher training. Nevertheless there is a risk that if such training is not carefully designed, it may inadvertently employ teacher-centred instruction, which would have the effect of paradoxically undermining the philosophical basis of the learner-centred teaching model.

The principal aim of this research is to test the assumption that university professors still display traditional teaching styles and whether any of the seven factors (see PALS further in the text) that define their teaching styles are in fact learner-centred. Finally the paper will compare university professors’ teaching styles across gender and faculty types.

THEORETICAL FRAMEWORK

Teachers’ beliefs about education help teachers choose instructional content, set teaching objectives, develop instructional materials, engage in interaction with learners, and evaluate overall outcomes of both teaching and learning processes. These educational beliefs, which constitute frameworks by which teachers as individuals of varied backgrounds reflect on their behaviours, are described with the phenomenon of *personal educational philosophy* [2]. However, while the teachers’ beliefs about what they do and their beliefs about what should be done are explained with the term of personal educational philosophy, what they actually do in their teaching settings is defined by the concept of *teaching style* – “the distinct qualities displayed by a teacher that are persistent from situation to situation regardless of the content” [3; p.76].

Conti [3] distinguishes between teacher-centred and learner-centred teaching styles. Teacher-centred styles are driven by the assumption that learner is naturally passive and is turned active after being stimulated to do so. The aim in the end of the stimulation is a ‘desired behaviour’. Thus the teacher is engaged in designing an atmosphere where desired behaviours are stimulated and the undesired behaviours are discouraged. Conti states that this approach to learning assumes that “motivation arises either from basic organic drives and emotions or from a tendency to respond in accordance with prior conditioning” [3; p.77]. Consequently, behavioural objectives are set and measured by criterion- or norm-referenced approaches, and outcomes are described “as competencies which the student must display after completing the educational activity” [3; pp.77-78].

On the other hand, learner-centred styles are driven by the assumption that every learner has an unlimited potential for personal growth. Therefore, personal perceptions define the desired behaviour. Motivation is a result of “people’s attempts to achieve and maintain order in their lives” [3; p.78]. The learner’s experience is of great importance and the learner is responsible for her/his own actions. The outcomes are measured by self-evaluation, which should be followed by “constructive feedback from the teacher and other learners” [3; p.78]. There is always present an attempt to match content and manner of presenting it with the learner and her/his needs.

The question of what style university teachers should adopt in the classroom is highly difficult to answer because personal educational philosophies vary. Mocić [4] surveyed three hundred and sixty students of the University of Pula and concluded that “the method of lecturing is the dominant one [...] but with a frequent use of guided conversations and discussions” [4; p.97]. The results imply university teachers’ tendencies to mainly adopt the teacher-centred rather than the learner-centred style.

Learner-centred styles, however, appear to be more effective if some of the theories of adult education are used as a reference point. For example, Mezirow [5] developed a theory where

knowledge is a product of the self-awareness resulting from critical reflection and critical self-reflection. According to Mezirow, the desired 'transformation' or learning is a personal process, and it is the learner who is the agent of change. The context or a situation is just a stimulator of a certain capacity. This way of reasoning strongly facilitates the learner-centred model of education since it prescribes a very active role to the learner in the process of transformation of values, assumptions, and convictions.

Like Mezirow, Jarvis [6] also attaches great importance to the phenomenon of experience and its potential follow up. Qualifying reflective learning as superior to other types of learning, Jarvis places importance on an experience and a route an individual follows afterwards. According to his model, a successful learning requires reflection which then upgrades learner's biography, "all that a person is at a particular point in time" [6; p.284], and directs reactions in subsequent situations.

Cross [7] defines learners by their personal and situational characteristics. While personal characteristics comprise physical, psychological, and sociocultural dimensions, which are continua and reflect growth and development from childhood into adult life, situational characteristics focus on variables unique to adult participants; for instance, whether it is part-time or full-time learning, or whether it is voluntary or compulsory participation. It might be considered as incorporating aging, stage, and phase developmental studies, participation learning projects, and motivation. As Mezirow and Jarvis do, Cross also attempts to explain that attitudes towards learning are being affected by contextual sets of factors which reveal rather dynamic forms. While a person acts on an environment through decisions and choices, the environment acts back by offering or not offering the chance for transformation of certain personal aspects.

According to the Knowles' model [8] the learner enters the instructional process with a set of physical and psychosocial characteristics which may or may not be matched. In other words, such learner may be both empowered and depowered through either andragogical or pedagogical approaches. The learner's experience or inexperience is of utmost importance and as such is a powerful stakeholder in the learning process. Furthermore, the learner's self-awareness of the amount and kind of experience which is applicable or inapplicable in a learning situation is as powerful stakeholder as experience itself.

Mezirow, Jarvis, Cross, and Knowles identified relationships between learners' personal and situational characteristics; consequences of learners' decisions to reflect or not on learning experiences; and ongoing interrelations between personal skills, knowledge and attitudes which might be contextually restrained and fostered. Their reasoning is at the heart of learner-centred educational philosophy and allows researchers to identify learner-focused characteristics as a reference point in curricula writing tasks.

PRINCIPLES OF ADULT LEARNING SCALE

Conti developed the Principles of Adult Learning Scale (PALS) inventory in which he identified seven factors of which a teaching style is comprised [3; pp.79-91]:

- Learner-centred Activities,
- Personalizing Instruction,
- Relating to Experience,
- Assessing Student Needs,
- Climate Building,
- Participation in the Learning Process,
- Flexibility for Personal Development.

The presence or absence of *Learner-centred Activities* in a classroom might be used as one of the indicators defining a teacher's teaching style. For example, the teacher who always uses disciplinary action when needed, encourages students to adopt middle class values, determines the educational objectives for students her/himself, plans units which differ as widely as possible from the students' socio-economic backgrounds, gets students to motivate themselves by confronting them in front of their classmates, uses one basic teaching method because she/he has found that most adults have a similar style of learning, uses written tests to measure the degree of academic growth, uses formal tests as her/his chief method of evaluating the students, uses methods that foster quiet, productive desk work, and uses materials that were originally designed for students in elementary and secondary schools, is teaching in the highly teacher-centred mode. The opposite preferences indicate a learner-centred orientation.

Personalizing Instruction is a factor that measures the extent to which the learning process is personalised in order to meet the needs of each student. A learner-oriented teaching style lets the lesson and process of learning pace itself – older students are allowed more time to complete the tasks when they need it. Different techniques depending on the students being taught are used. In opposite, a teacher-oriented teaching style favours lecturing and does not base objectives on individual motives and abilities. The same assignments on a given topic are given to all the students and competition is encouraged.

Relating to Experience is the third factor defining the educator's style. If an educator takes into account a learner's prior experience and tries to make the learner relate new learning experiences to the prior ones, she/he is practicing a learner-centred approach. Learner-centred teaching also stimulates learner's independence in the learning process and organizes learning tasks in the way they could be encountered in everyday life. If all of these above are absent in the teaching style, the style is teacher-centred.

The way of *Assessing Student Needs* is the fourth indicator of one's teaching style. If an educator counsels their students informally, takes into account the learners' goals and helps them see the gaps between their goals and the current performance, and if she/he helps them develop both short-range and long-range objectives, her/his teaching style bears the learner-centred characteristics. If not, then the teacher adopts the teacher-oriented style.

The teaching style might also be defined by *Climate Building* in an educational setting. If the teacher fosters development of a friendly and informal atmosphere in a classroom and dialogue among the students, if she/he accepts errors as a natural part of the learning process and stimulates risk-taking which will help students explore and develop their interpersonal skills, if the failure is used as a feedback in the learning to come, the teacher possesses a learner-centred teaching style. If the opposite is practiced, the teacher is teacher-oriented.

Participation in the Learning Process is the sixth factor in defining the type of teaching style. This concept identifies if teacher provides a chance to learners to participate in developing the criteria for evaluating their performance in class. It also asks if the teacher arranges the classroom in the way that students could easily communicate, if students can participate in making decisions about the topics to be covered and whether they are allowed to identify their own problems to be solved. If answers to all the questions asked are positive, the respondent has a highly learner-centred teaching style. If answers to all the questions are negative, then the respondent favours teacher-oriented approach to teaching.

The last factor looks for *Flexibility for Personal Development*. If an educator provides the knowledge rather than facilitates it, if she/he determines the objectives for the students before the program starts and does not abandon or change them until the end of it, if the disciplined class is found stimulatory for learning, if relating to student's self concept is avoided, the respondent displays a teacher-centred style. On the other hand, if the personal fulfilment is

aimed and if to do so flexibility is maintained through the process, the style under the scope is the one of learner-centred nature.

Oslund [9] conducted a meta-analysis of dissertations that utilized the PALS instrument. He analysed “fifty-five dissertations [...] with nearly 5 300 subjects” [9; p.x]. Oslund classified the dissertations as “(a) four-year colleges; (b) two-year colleges; [and] (c) other educators” and found that the “PALS composite mean was statistically significant for each group, and within one standard deviation of the norm mean ($M = 146$) [which categorises them as] intermediate teacher-centred” [9; p.x].

Ahmed [10] surveyed twenty-two university instructors at the Midwestern University utilizing the PALS. The respondents were “teaching graduate classes at the Department of Educational Leadership, the Department of Educational Studies, the Department of Special Education, and the Department of Elementary Education” [10; p.25]. The study results show that the respondents adopted both the teacher- and learner-centred instructional practices with the overall mean score of 144,55 ($SD = 16,62$). Ahmed found no significant relationship “between the instructor’s age and his/her teaching style [...] and] between the instructor’s teaching style and the overall years of teaching experience or the teaching experience at the Midwestern University” [10; p.22].

METHOD

Fifty-two ($N = 52$) university teachers employed at International University of Sarajevo were surveyed with the Principles of Adult Learning Scale (PALS) designed by Conti [3]. The responses were scored according to guidelines provided by the survey author. The scores were compared across the respondents’ genders and faculties.

RESEARCH QUESTIONS

RQ1: What are the teaching style preferences of International University of Sarajevo instructors as measured by the *Principles of Adult Learning Scale (PALS)* inventory?

RQ2: Is there any difference in teaching style preferences between female and male respondents?

RQ3: Is there any difference in teaching style preferences across the faculties of Arts and Social Sciences (FASS); Business and Administration (FEBA); and Engineering and Natural Sciences (FENS)?

PARTICIPANTS

Forty-four of the participants ($N = 44$) were Bosnians and eight of them ($N = 8$) were foreigners. Twenty-six ($N = 26$) females and twenty-six ($N = 26$) males participated in the study. Thirteen of them ($N = 13$) taught at the Faculty of Arts and Social Sciences (FASS), eleven of them ($N = 11$) taught at the Faculty of Business and Administration (FEBA), and twenty-eight of them ($N = 28$) taught at the Faculty of Engineering and Natural Sciences (FENS).

INSTRUMENT

The Principles of Adult Learning Scale (PALS) is composed of forty-four Likert-type items which elicit six answers: Always, Almost Always, Often, Seldom, Almost Never, and Never. The instrument places a respondent’s teaching style on a continuum between extreme teacher- and extreme learner-centred teaching style poles. The survey items are in the form of statements describing teaching actions such as *I arrange the classroom so that it is easy for students to interact* or *I use different techniques depending on the students being taught*. Conti granted “the permission for practioners and researchers to reproduce and use the Principles of Adult learning Scale in their work” [3].

DATA ANALYSIS

Conti [3] provided scoring guidelines for his instrument. Scoring involves converting the values for the positive items and then summing the values of the responses to all items. Scores may range from 0 to 220. The average for PALS is 146 with a standard deviation of 20. Respondent's overall teaching style and the strength of respondent's commitment to that style can be judged by comparing the score to 146. Scores above 146 indicate a tendency toward the learner-centred mode while lower scores imply support of the teacher-centred approach. Most scores are expected to be within one standard deviation of the mean; that is, they are expected to be between 126 and 166. Movement toward these scores indicates an increased commitment to a specific teaching style. Scores which are in the second standard deviation of 20 to 40 points indicate a very strong and consistent support of a teaching style. Scores that are in the third standard deviation and are at least 40 points from the mean indicate an extreme commitment to a style.

The overall PALS score can be analysed across seven factors (see Table 1). Each factor contains a similar group of items that make up a major component of a teaching style. High scores in each factor represent support of the learner-centred concept implied in the factor name. Low factor scores indicate support of the opposite concept. Factor scores are calculated by adding up the points for each item in the factor.

Table 1. Originally suggested reference points for classifying the factors as teacher- (if lower than the mean) or learner-centred (if higher than the mean) [3].

| Factor No. | Factor Name | Mean | Standard Deviation |
|------------|---------------------------------------|------|--------------------|
| 1 | Learner-centred Activities | 38 | 8,3 |
| 2 | Personalizing Instruction | 31 | 6,8 |
| 3 | Relating to Experience | 21 | 4,9 |
| 4 | Assessing Student Needs | 14 | 3,6 |
| 5 | Climate Building | 16 | 3,0 |
| 6 | Participation in the Learning Process | 13 | 3,5 |
| 7 | Flexibility for Personal Development | 13 | 3,9 |

The scores, means, and standard deviations of the responses were calculated using SPSS 21.0 package. The same package was used for performing independent *t*-test and one-way ANOVA tests with which differences in means between respondents' genders and faculties were tested. The Shapiro-Wilk's test ($p > 0,05$), visual inspection of their histograms, normal Q-Q plots and box plots showed that the teaching style scores approximated a normal distribution for both females and males across the three faculties. In addition, the assumption of homogeneity of variances was tested and satisfied via Levene's *F* test.

RESULTS

RQ1

The descriptive statistics associated with teaching style types (*teacher-centred* < 146 < *learner-centred*) across the three teacher groups are reported in Table 2. It can be seen that respondents regardless of the faculty background and gender strongly support the teacher-centred teaching style with arithmetic mean considerably lower than 146 ($M_{FASS} = 120,53$, $M_{FEBA} = 115,63$, $M_{FENS} = 112,96$, $M_{MALE} = 115,76$, $M_{FEMALE} = 115,07$).

RQ2

The independent *t*-test revealed no statistically significant difference between female and male teachers' preferences for a teaching style, $t(50) = 0,17$, $p > 0,05$. The descriptive statistics associated with factors comprising teaching styles across genders are reported in Table 3.

Table 2. Overall means and standard deviations of teaching style scores across respondents' faculties and genders.

| | | | | | | | |
|-------|----|--------|------------------------|--------|----|--------|------------------------|
| FASS | M | 120,53 | Teacher-centred (<146) | Male | M | 115,76 | Teacher-centred (<146) |
| | N | 13 | | | N | 26 | |
| | SD | 15,76 | | | SD | 13,77 | |
| FEBA | M | 115,63 | Teacher-centred (<146) | Female | M | 115,07 | Teacher-centred (<146) |
| | N | 11 | | | N | 26 | |
| | SD | 11,57 | | | SD | 15,30 | |
| FENS | M | 112,96 | Teacher-centred (<146) | | | | |
| | N | 28 | | | | | |
| | SD | 14,61 | | | | | |
| Total | M | 115,42 | Teacher-centred (<146) | | | | |
| | N | 52 | | | | | |
| | SD | 14,41 | | | | | |

Table 3. Means and standard deviations of factors comprising teaching styles per gender.

| Factor No: | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------------|----|-------|-------|-------|-------|-------|-------|-------|
| Male | M | 31,35 | 22,50 | 18,35 | 11,96 | 13,04 | 9,19 | 9,38 |
| | N | 26,00 | 26,00 | 26,00 | 26,00 | 26,00 | 26,00 | 26,00 |
| | SD | 5,82 | 5,49 | 4,11 | 2,58 | 2,51 | 2,61 | 3,26 |
| Female | M | 30,08 | 20,12 | 17,35 | 12,62 | 14,96 | 10,08 | 9,88 |
| | N | 26,00 | 26,00 | 26,00 | 26,00 | 26,00 | 26,00 | 26,00 |
| | SD | 5,77 | 3,94 | 5,46 | 3,88 | 2,68 | 4,22 | 4,23 |

Referring to the suggested score interpretations (see Table 1), it can be concluded that each factor's arithmetic mean of both genders' responses is closer to the teacher-centred pole than to the learner-centred pole.

RQ3

No statistically significant difference was found between the teaching styles across the three faculties as determined by the one-way ANOVA [$F(2,49) = 1,24, p = 0,30$]. The descriptive statistics associated with factors comprising teaching styles across the three faculties are reported in Table 4. Referring to the suggested score interpretations (see Table 1), it can be concluded that each factor's arithmetic mean of each faculty group is closer to the teacher-centred than to the learner-centred pole.

Table 4. Mean and standard deviations of factors comprising teaching styles per faculty.

| Factor No: | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------------|----|-------|-------|-------|-------|-------|-------|-------|
| FASS | M | 33,38 | 22,30 | 18,53 | 11,69 | 13,61 | 9,30 | 11,69 |
| | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | SD | 5,72 | 4,83 | 4,01 | 2,95 | 2,63 | 2,62 | 3,03 |
| FEBA | M | 27,09 | 20,81 | 19,45 | 13,27 | 15,72 | 12,00 | 7,27 |
| | N | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| | SD | 6,04 | 3,99 | 6,18 | 4,71 | 2,28 | 4,42 | 3,82 |
| FENS | M | 30,89 | 21,03 | 16,89 | 12,17 | 13,50 | 8,85 | 9,60 |
| | N | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| | SD | 5,10 | 5,29 | 4,49 | 2,76 | 2,76 | 3,14 | 3,56 |
| Total | M | 30,71 | 21,30 | 17,84 | 12,28 | 14,00 | 9,63 | 9,63 |
| | N | 52 | 52 | 52 | 52 | 52 | 52 | 52 |
| | SD | 5,77 | 4,88 | 4,81 | 3,27 | 2,74 | 3,50 | 3,74 |

DISCUSSION

The findings of this study are partly aligned with the findings reported by Mocinic [4] and Oslund [9] who found that university teaching is predominately based on the transmission model where the teacher is the active source of information and the student a passive recipient. Mocinic [4] and Ahmed [10] reported cases of non-traditional teaching techniques as well. This research also indicates that some university professors do not fully conform to the traditional teaching approaches. The arithmetic means of the scores presented in Table 2, 3 and 4 indicate that the respondents support teacher-centred ways. However, the analysis of their individual scores reveals the range between 82 (very strong teacher-centred style) and 150 (a weak learner-centred style) (Figure 1). Two out of fifty-two respondents scored higher than 146 points in the survey. Twelve of them scored between 126 and 146 points. And this shows that some respondents' have tendencies to balance their teaching styles. Therefore, it may be concluded that while the learner-centred teaching style is possible it is not often adopted by university teaching staff.

The interpretation of the results does not present a positive view in relation to the adoption of learner-centred instruction in university teaching. The results clearly reveal a strong teacher-centred method of instruction, which is independent of gender and scientific field background. The reasons for the elusiveness of the learner-centred teaching style may lie in understanding of the required conditions for learner-centred instruction.

One way to promote a learner-centred style may be the inclusion of instructional activities that meet the individual needs of every learner profile into a curriculum. This would require careful diagnosis of learner needs. The corollary is flexible approaches to curricula writing, assessment, and instructional material design. It is recognised, however, that where instructors are teaching several courses to different groups of students, the task of a thorough needs analysis would not be feasible. In such cases flexible curricula could not be designed and formal assessment methods were inevitable.

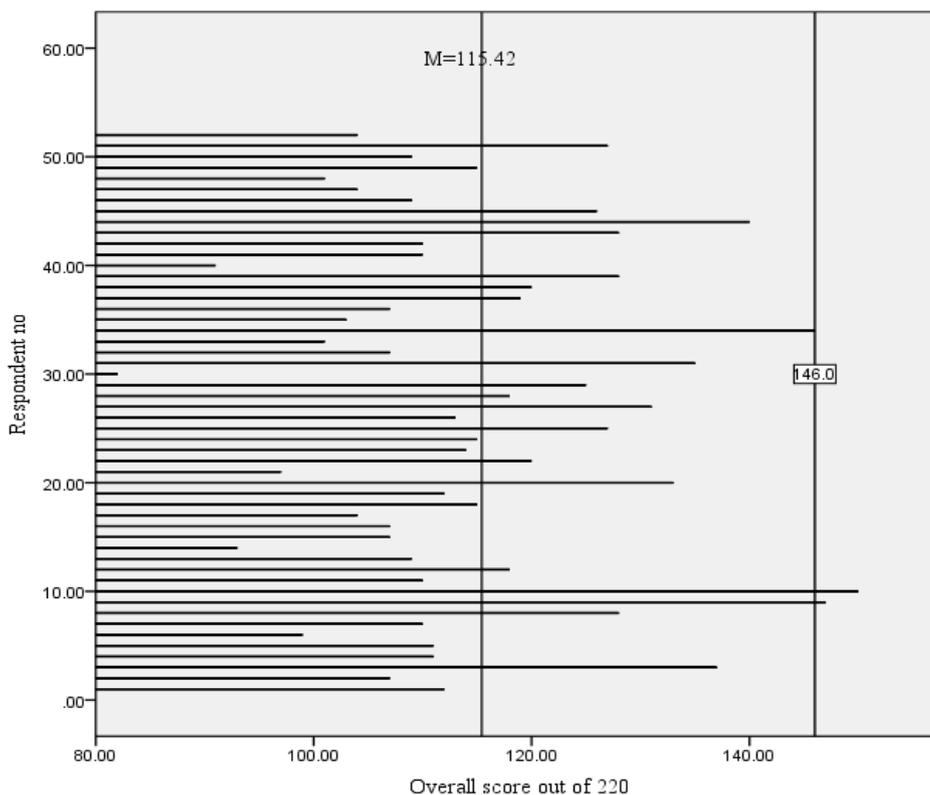


Figure 1. Respondents' individual scores.

Nevertheless some of the requirements for the learner-centred instruction style can be met if we assume the instructor is not the only source of information. Modern technology has made knowledge quite accessible. Yet the classroom time planning becomes a challenge if lecturing is completely abandoned because students expect teachers to be a source of knowledge [11, 12]. In addition, allocating time for individual student instruction during a lesson could lead to neglecting learning needs of other students. Advising instructors to focus their attention on particular students has been used as a remedy to treat random and unpredictable learners' needs.

An effective learner-oriented teaching style should allow the learning process to pace itself. However, this is not always possible because undergraduate university programs are subject to institutional, national, and international regulations. Consequently, the number of lessons per semester, exam dates, and learning outcomes are often set before an instructor starts the instructional process. And where a student is not ready for a test and elects not to take it, she/he will fail. Hence most university instruction is pushed towards the teacher-centred pole by higher-education stakeholders because it is easier to administer.

Stimulating learners' independence will make a teaching-style more learner-centred. Yet undergraduate university programs emphasise the need to acquire the knowledge and expertise needed in the job market. Since it is assumed that university teachers are experts in their specific fields, the prioritising of material delivery seems to be a logical choice. While research-based instruction in postgraduate programs by definition will stimulate student independence, the degree that the same type of instruction can be integrated into undergraduate programs will depend on individual learner-profiles and the number of students per course. Knowles [8] explains that every andragogue (learner-centred instructor) will behave as a pedagogue (teacher-centred instructor) if students depend on her/him.

Another factor that militates against learner-centred teaching is the lack of financial and academic resources. Facilities such as huge amphitheatres and classrooms, which often mark university settings, are not designed for learner-centred instruction. Learner-centred instruction is only fully possible in small classes. For example, Rogers [13] suggests that the number of learners per group should be somewhere between ten and twenty-five. This requirement may in the end be too costly for limited university budgets because it requires rebalancing of the students-per-teacher ratio.

But even if detailed needs analyses, flexible curricula, less formal assessment, and learning independence are difficult to integrate into contemporary university programs, this does not necessarily mean that learner-centred instruction is impossible. A friendly classroom atmosphere that stimulates life-long learning goals and fosters interpersonal skills can move instruction towards the learner-centred pole. Rearranging the traditional way of sitting, incorporating the students' suggestions about topics to be covered and integrating their own knowledge and experiences into classroom time are also features of learner-centred style. A learners' personal fulfilment should not be overlooked since it is a strong element that affects their overall dedication to learning. Burden advises teachers to "build and maintain [learning] group cohesiveness" defining group cohesiveness as "the extent to which the group has a sense of identity and oneness" [14; p.232]. Two of the nine ways he suggests are *engaging students in cooperative activities* and *increasing the frequency of interaction*. By fostering collaboration, the teacher improves the quality of teaching climate. According to Underwood [15] a happy, purposeful, and supporting atmosphere could be achieved by *including every student in some way during each lesson* and *providing opportunities for the students to talk and listen to each other*.

According to Vassiliou [1], the 2010-2014 European Commissioner for Education, Culture, Multilingualism and Youth, "the online and open education world is changing how education

is resourced, delivered and taken up [...] But many universities are not yet ready for this change” [1; p.4]. Vassiliou concludes that there is a lack of national and institutional strategies which could increase dependence on technologically advanced tools and invites “The High Level Group for the Modernisation of Higher Education to set out recommendations on enhancing higher education through new technologies.” Their subsequent report states the following [1; pp.18-19]: *Students are unique, and so is the way they learn. Therefore, the teaching tools used in universities and colleges should cater for individual ways of learning, with the student at the centre [...] This connects very strongly with the Group’s last report, which focused on enhancing the quality of teaching and learning in higher education. Its recommendations called for a change in attitudes towards the teaching mission, by introducing greater professionalism in teaching, more student engagement in the learning process and better recognition of good teaching.*

It is argued in the Group’s previous report that “higher education institutions need to create environments and feedback mechanisms and systems to allow students’ views, learning experience, and their performance to be taken into account” [16; p.28]. The following is stated in the same report [16; p.40]: *The notion of student-centred learning has been around for many years now but its implications are still not realised by many academics or, indeed, students. It is not yet widely understood – or at least, acted upon – that student-centred learning means that the teacher’s role should shift from imparting knowledge to guiding the student in his or her own learning.*

Another of their recommendations is that “continuous professional education as teachers should become a requirement for teachers in the higher education sector” [16; p.31]. Calling on Zinn [2] Powell also argues that the instructors who were trained in adult learning theory are more likely to display teaching behaviours that answer the needs of adult learners [17, 18].

CONCLUSION

The results of this research show that learner-centred instruction is not widely spread among university professors because there is still a strong adherence to teacher-centred instruction. In the above discussion assumptions were made about the reasons behind these findings. It is recognised, however, that further empirically grounded research is required to fully explore the reasons for this finding.

Empirical data for this research was collected at a small private university. This is a significant factor in terms of the research results because private universities are not usually subject to the same stringent bureaucratic procedures found in the ‘bigger’ universities. Therefore it is reasonable to assume that teacher-centred educational models are still deeply embedded in teaching practice. Additionally, this research shows that the predominant teaching norms are shared across very different scientific fields. Indeed it is significant that very similar teaching styles are evident in both the social and natural sciences. It is apparent that the national and international higher-education agencies should re-evaluate the ways in which they are coordinating university instruction if learner-centred model of education is to be widely adopted.

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FUZZY-GENETIC CONTROL OF QUADROTOR UNMANNED AERIAL VEHICLES

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ABSTRACT

This article presents a novel fuzzy identification method for dynamic modelling of quadrotor unmanned aerial vehicles. The method is based on a special parameterization of the antecedent part of fuzzy systems that results in fuzzy-partitions for antecedents. This antecedent parameter representation method of fuzzy rules ensures upholding of predefined linguistic value ordering and ensures that fuzzy-partitions remain intact throughout an unconstrained hybrid evolutionary and gradient descent based optimization process. In the equations of motion the first order derivative component is calculated based on Christoffel symbols, the derivatives of fuzzy systems are used for modelling the Coriolis effects, gyroscopic and centrifugal terms. The non-linear parameters are subjected to an initial global evolutionary optimization scheme and fine tuning with gradient descent based local search. Simulation results of the proposed new quadrotor dynamic model identification method are promising.

KEY WORDS

quadrotor UAV, fuzzy system, unconstrained optimization, genetic algorithms, gradient descent search

CLASSIFICATION

ACM: G.1.6.

JEL: Z19

PACS: 45.40.-f,87.19.lu

INTRODUCTION

A wide area of robotics research is dedicated to aerial platforms. The quadrotor architecture has low dimensions, good manoeuvrability, simple mechanics and payload capability.

The study of kinematics and dynamics helps to understand the physics of the quadrotor and its behaviour. Together with modelling, the determination of the control algorithm structure is very important [1-6]. The quadrotor unmanned aerial vehicle (UAV) is controlled by angular speeds of four motors. Each motor produces a thrust and a torque, whose combination generates the main thrust, the yaw torque, the pitch torque, and the roll torque acting on the quadrotor. Motors produce a force proportional to the square of the angular speed and the angular acceleration; the acceleration term is commonly neglected as the speed transients are short thus exerting no significant effects. Soft computing methods can be efficiently applied together with and also instead of conventional controllers.

Fuzzy modelling [7-12] can be conducted as black-box modelling where all the system knowledge is mere input-output data, however when expert knowledge is readily available, we should take advantage of it – fuzzy grey-box modelling is a rational choice. Identification of linear parameters is a well-studied area, with efficient matrix algebra and singular value decomposition based reliable tools. Non-linear parameters can also be simply traced to their local optimum with well-studied gradient descent methods, but we should always keep in mind that gradient descent methods are trapped by local optimum areas. Evolutionary algorithms are robust global optimum search engines, capable of multi-objective search as described in [13-16].

The article is organized as follows. In Section 1 the Introduction is given, in Section 2 the quadrotor dynamic model is presented. In Section 3 the Fuzzy-logic systems are illustrated. In Section 4 the multi-objective Genetic algorithms are illustrated. Section 5 presents the simulation setup and simulation results. Conclusions are given in Section 6.

QUADROTOR DYNAMIC MODEL

Motors of a quadrotor can only turn in a fixed direction, so the produced force is always positive. Motors are set up so that two opposites form a pair, which turns clockwise, while the other pair rotates counter-clockwise. This arrangement is chosen so that gyroscopic effects and aerodynamic torques are canceled in trimmed flight [17-20].

The main thrust is the sum of individual thrusts of each four motor. The pitch torque is a function of difference in forces produced on one pair of motors, while the roll torque is a function of difference in forces produced on other pair of motors. The yaw torque is sum of all four motor reaction torques due to shaft acceleration and blades drag. The motor torque is opposed by a general aerodynamically drag.

The complete dynamics of an aircraft, taking into account aero-elastic effects, flexibility of wings, internal dynamics of the engine, and the whole set of changing environmental variables is quite complex and somewhat unmanageable for the purpose of autonomous control engineering.

For a full dynamic model of a quadrotor system both (1) the center of mass position vector of (x, y, z) in fixed frame coordinates and (2) the orientation Euler angles: roll, pitch, yaw angles (Φ, θ, ψ) around body axes X, Y, Z are considered for the vector of generalized coordinates q . Using the Euler-Lagrange approach it can be shown how the translational forces \mathbf{F}_ξ applied to the rotorcraft due to main thrust can be full decoupled from the yaw, pitch and roll moments. For a full dynamic model of a quadrotor system both (1) the center of mass position vector of (x, y, z) in fixed frame coordinates and (2) the orientation Euler angles: roll, pitch, yaw angles

(ϕ, θ, ψ) around body axes X, Y, Z are considered for the vector of generalized coordinates q . Using the Euler-Lagrange approach it can be shown how the translational forces \mathbf{F}_ξ applied to the rotorcraft due to main thrust can be full decoupled from the yaw, pitch and roll moments $\boldsymbol{\tau}$:

$$m \begin{bmatrix} \ddot{x} \\ \ddot{y} \\ \ddot{z} \end{bmatrix} + mg \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \mathbf{F}_\xi, \quad (1)$$

where m is the quadrotor mass and g is the gravitational constant.

$$\mathbf{J} \begin{bmatrix} \ddot{\phi} \\ \ddot{\theta} \\ \ddot{\psi} \end{bmatrix} + \mathbf{C} \left(\begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix}, \begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix} \right) \begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix} = \boldsymbol{\tau}, \quad (2)$$

where \mathbf{J} is a 3×3 matrix, called the inertia matrix and \mathbf{C} is also a 3×3 matrix that refers to Coriolis, gyroscopic and centrifugal terms. Further on, for the scope of this article we shall address only equation (2) as the quadrotor dynamic model to be identified.

Equation (2) can be analyzed as three resultant torques τ_i acting along the i^{th} axes respectively as $i \in (\phi, \theta, \psi)$, which using Christoffel symbols of the first kind can be defined as a function of the state vector of Euler angles $\mathbf{q} = (\phi, \theta, \psi)$, their velocities ($\dot{q} = dq/dt$) and accelerations ($\ddot{q} = d\dot{q}/dt$) as:

$$\sum_j (D_{ij}(q) \cdot \ddot{q}_j) + \sum_{j,k} (\dot{q}_j \cdot D_{ijk}(q) \cdot \dot{q}_k) = \tau_i, \quad i, j, k = 1, 2, 3. \quad (3)$$

The first component of equation (3) is shortly referred to as $\mathbf{J}\ddot{\mathbf{q}}$ the inertia matrix part, while the second as $\mathbf{C}\dot{\mathbf{q}}$ the Coriolis matrix term for which components are defined as:

$$J_{ik} = D_{ik}(q), \quad C_{ik} = \sum_{j=1}^p \dot{q}_j \cdot D_{ijk}(q), \quad i, j, k = 1, 2, 3. \quad (4)$$

Where D_{ik}, D_{ijk} are in general, highly non-linear scalar functions of the state vector q . They contain $\sin(\cdot)$ and $\cos(\cdot)$ functions of q , and their products and sums defined by the geometry of the system.

There are general relations that can be used for reducing the number of unknown elements of \mathbf{J} and \mathbf{C} , like: (1) \mathbf{J} is symmetric and (2) D_{ijk} are Christoffel-symbols of D_{ij} , thus further properties are inherently defined as:

$$D_{ik} = D_{ki}, \quad D_{ijk} = \frac{1}{2} \left(\frac{\partial D_{ij}}{\partial q_k} + \frac{\partial D_{ik}}{\partial q_j} - \frac{\partial D_{jk}}{\partial q_i} \right), \quad D_{ijk} = D_{ikj}, \quad D_{kij} = -D_{jik}, \quad D_{kjk} = 0, \quad \forall i, k \geq j. \quad (5)$$

It should be noted that direct measurement of any single component from equation (4) is not possible; the only measurable data, on the output of the system, is the resultant torque of equation (3).

Identification of all non-linear functions (4) under these terms is a considerable problem.

FUZZY –LOGIC SYSTEMS

Takagi-Sugeno-Kang (TSK) type Fuzzy-logic systems (FLSs) having n inputs and 1 output are defined as:

$$f(q) = \frac{\sum_{l=1}^M \omega_l(q) \cdot y_l(q)}{\sum_{l=1}^M \omega_l(q)}, \quad (6)$$

where M is the number of rules, q is the vector of n input variables, y_l is a scalar function of n input variables, defined by $(n + 1) \cdot c$ parameters as in equation (8). The antecedent, the premise part of a fuzzy rule is:

$$\omega_l(q) = \prod_{i=1}^n \mu_{F_{l(i)}}(q_i), \quad (7)$$

where $\mu_{F_{l(i)}}(q_i)$ is the membership function (MF) of the i^{th} input variable in the l^{th} rule that defines the linguistic value $F_{l(i)}$. The linguistic form of the l^{th} rule from the previously described first order TSK FLS is defined in [13] as:

$$\text{IF } (q_1 \text{ is } F_{l(1)}) \text{ AND } (q_2 \text{ is } F_{l(2)}) \text{ AND } \dots (q_n \text{ is } F_{l(n)}) \text{ THEN } y_l = \sum_{j=1}^n c_{l(j)} \cdot q_j + c_{l(0)}, \quad (8)$$

Zadeh-formed MFs are the z-, the s-, and π -functions (named after their shape) defined respectively as:

$$mfz(q, b_1, b_2) = \begin{cases} 1 & q \leq b_1 \\ 1 - 2((q - b_1)/(b_2 - b_1)) & b_1 < q \leq \frac{1}{2}(b_2 + b_1) \\ 2((q - b_1)/(b_2 - b_1)) & \frac{1}{2}(b_2 + b_1) < q \leq b_2 \\ 0 & q > b_2 \end{cases}$$

$$mfs(q, b_1, b_2) = 1 - mfz(q, b_1, b_2) \quad (9)$$

$$mf\pi(q, b_1, b_2, b_3, b_4) = \begin{cases} mfs(q, b_1, b_2) & q \leq b_2 \\ 1 & b_2 < q \leq b_3 \\ mfz(q, b_3, b_4) & q > b_3 \end{cases}$$

where $b_1 \leq b_2 \leq b_3 \leq b_4$ are parameters defining MFs. In case there is more than one value q such that the degree of membership of q is equal to one, the interval where $\mu_k(q, b) = 1$ (the interval $[b_2, b_3]$ for $mf\pi$ type μ_k) is called the plateau of the μ_k MF. When having for example 3 naturally ordered linguistic values $l \in \{a, b, c\}$ ($a \leftrightarrow \text{low}$, $b \leftrightarrow \text{medium}$, $c \leftrightarrow \text{large}$) constraints on parameters to preserve this ordering are:

$$\begin{aligned} b_{a1} &< b_{b1} < b_{c1}, \\ b_{a2} &\leq b_{a3} < b_{b2} \leq b_{b3} < b_{c2} \leq b_{c3}, \\ b_{a4} &< b_{b4} < b_{c4}. \end{aligned} \quad (10)$$

A linguistic variable can be assigned K different linguistic values, each described by a MF $\mu_k(q, b)$ such that for every input x it holds that $\sum_{k=1}^K \mu_k(q, b) = 1$, the MFs are said to form a fuzzy-partition. Forming fuzzy-partitions by antecedent membership functions ensures that there can not be a numerical input within the defined input range that will not result in firing at least one rule consequent of the fuzzy model, which means that there is a defined output for all possible input states. Keeping specific properties of fuzzy-partitions imposes a set of hard constraints on membership function parameters as detailed in [15]. By imposing these restrictions on all linguistic variables of the FLS, and additionally assuming that the rule base is complete in the sense that it covers the whole input domain, it immediately follows that the TSK model structure of equation (6) simplifies to:

$$f(q) = \sum_{l=1}^M \omega_l(q) \cdot y_l(q). \quad (11)$$

Automatic fine tuning FLS parameters that satisfies all of above listed constraints is a significant problem.

In [15] a method is introduced that simplifies parameter optimisation of equation (11) while preserving all required constraints. Fuzzy-partitions can be simply formed from Zadeh-typed MFs by making equal the last two parameters of each preceding MF to the first two parameters of the succeeding MF. This way a fuzzy partition of K MFs is defined by $2(K-1) + 1$ parameters. Let our input space be normalised ($x_{\min} = 0$ and $x_{\max} = 1$). If we do not want to allow any plateaux, parameter b_2 must be equal to b_3 in equation (9) this way the number of parameters is further reduced to $K - 2$. When we take into consideration all constraints of equation (10), we end up with a series of strictly ordered parameters:

$$b_1 < b_2 < \dots < b_{K-1}. \quad (12)$$

Let us add two more constraints:

$$0 < b_1 \text{ and } b_{K-1} < 1. \quad (13)$$

Let us define the first MF to be:

$$mfz(x, 0, b_1). \quad (14)$$

Let the K -th, the last MF concluding the fuzzy partition be:

$$mfs(x, b_{K-2}, 1). \quad (15)$$

Let us define intermediate k th MFs to be:

$$mf\pi(x, b_{k-1}, b_k, b_k, b_{k+1}) \quad (16)$$

for $k = 1, \dots, K-2$, where $b_0 = 0$ and $b_{K-1} = 1$. This way the ordered series of $K-2$ parameters b_i , together with constants 1 and 0, are the minimal number of parameters to define a fuzzy-partition of Zadeh-formed MFs. This minimal number of non-linear parameters is a very important issue for optimisation as over parameterised systems are hard to optimise. The only problem is that when tuning the non-linear parameters of a FLS having an n dimensional input space, we must comply with $\sum_{i=1}^n K_i$ pieces of hard constraints. Although there are a number of constrained optimisation methods it is obvious that an unconstrained optimisation method would be more efficient. Let us consider $K - 1$ pieces of rational, positive or zero parameters as proposed in [12]:

$$a_{\kappa} \in R_0^+, \quad \kappa = 1, \dots, K - 1. \quad (17)$$

When we define b_k as:

$$b_k = \sum_{j=1}^k a_j / \sum_{\kappa=1}^{K-1} a_{\kappa}. \quad (18)$$

for every $k = 1, \dots, K - 2$; all the constraints of equation (12) and equation (13) are automatically fulfilled for every a_{κ} from equation (18) without any further restrictions on any a_{κ} , other than $0 \leq a_{\kappa}$. An ANFIS like optimisation, defined in [16] or any other efficient unconstrained nonlinear numerical method can be applied to minimise equation (11) error along the a_{κ} parameters. For calculating all linear parameters a linear least square (LS) method can be applied to $c_{l(j)}$ parameters of the consequent part. To avoid traps of local optimal solutions for a_{κ} , a preliminary global search should be applied.

MULTI-OBJECTIVE GENETIC ALGORITHMS

A genetic algorithm (GA) is constructed on bases of imitating natural biological processes and Darwinian evolution [21-24]. GAs are widely used as powerful global search and optimization tools [25]. Real life optimization problems often have multiple objectives. To establish ranking of chromosomes for Gas the comparison of two objective vectors is required. Often a simple weighted sum is used, but its drawbacks are widely known. Pareto based comparison [19] is the bases of a few popular methods like Non-dominated Sorting GA (NSGA) [22] and Multi-Objective GA (MOGA) [23, 25]. A general multi-objective

optimization problem consists of n number of scalar minimization objectives where every scalar objective function $f_i(x)$ is to be minimized simultaneously, where x is an n -dimensional vector of parameters. As maximization can be easily transformed to minimization, the generality of the previous statement stands. A vector x_1 Pareto-dominates x_2 , when no scalar component of x_2 is less than the appropriate component of x_1 , and at least one component of x_1 is strictly smaller than the appropriate component of x_2 . Since no metrics can be assigned to Pareto-dominance, there have been two different attempts to define a GA ranking method, which can be used for Pareto-dominance vector comparison: (1) “Block-type” ranking is defined in [23] as: *Rank* is equal to $1 + (\text{number of individuals that dominate the } i^{\text{th}} \text{ individual})$; (2) “Slice-type” ranking is defined in [5] as: *Rank* is equal to $1 + (\text{number of turns when the non-dominated individuals are eliminated, needed for the } i^{\text{th}} \text{ individual to become non-dominated})$.

Quantity-dominance, as proposed in [15] is defined as: vector $a = [a_i]$. Quantity-dominates vector $b = [b_i]$ if a has more such a_i components, which are better than the corresponding b_i component of vector b , and a has less such a_j components, which are worse than the corresponding b_j . A metrics can be defines as: the measurement of the extent of Quantity-dominance is the difference between the number of better and the number of worse components. For a measurement based ranking method the *Rank* of the i^{th} objective vector can be simply defined as *the sum of Quantity-dominance measurements for every individual measured from the } i^{\text{th}} \text{ vector}*. This ranking method can be readily applied with Quantity-comparison. The proposed vector comparison method provides more information when comparing two vectors than the classic Pareto-based comparison, thus the GA is faster, more efficient in its search. The MMNGA algorithm is computationally less expensive, and more efficient compared to the classical methods, and its results analyzed on a number of GA hard problems are at least equally good [16].

In case of multi-rotors the roll and pitch are equal to:

$$\phi = a \sin \frac{\dot{x} \sin \psi - \dot{y} \cos \psi}{\ddot{x}^2 + \ddot{y}^2 + (\ddot{z} + g)^2}, \quad \theta = a \tan \frac{\dot{x} \cos \psi - \dot{y} \sin \psi}{\ddot{z} + g}. \quad (19)$$

From equations (3) and (19) it is obvious that controll torques for multi rotors are direct functions of up to the fourth time derivatives of state variables (x, y, z) and ψ . To have realistic, feasible torques along a trajectory, which are efficiently controllable without chattering, we need smooth torque changes. Having $\tau = \tau(q, \dot{q}, \ddot{q})$ and $q = q(\psi, \dot{\psi}, \ddot{\psi})$ for smooth torque changes, we need smooth changes of the so called displacement crackle $c(t) = d^5 r / dt^5$, the fifth time derivative of displacement $r(x, y, z)$. Proposal of this article is to use a smooth displacement crackle function, which can be defined with a continuous displacement pop function $p(t) = d^6 r / dt^6$ as:

$$p(t) = G \frac{\sin(\omega_d \cdot t + \sigma_d)}{\omega_d}, \quad c(t) = \int p(t) dt = G [1 - \cos(\omega_d \cdot t + \sigma_d)] \quad (20)$$

where ω_d is the natural dampened frequency from equation (3), σ_d the phase delay is kept is zero, and the gain G is selected for each trajectory and system such that the required boundaries for displacement, velocity and acceleration limits are met. The integration constant for $c(t)$ is to be selected as equal to G to achieve the required properties for the crackle function; for all further integrations to calculate trajectory snap, jerk, acceleration, velocity and displacement by intergrating $c(t)$ we are to use integration constants equal to zero. The resulting general trajectory plot is as presented in Figure 1.

We can efficiently identify D_{ij} inertia matrix components of the dynamic model in equation (4) as FLSs defined by equations (11) to (18), where the FLS general input variable q will be

substituted for the appropriate state variables of (ϕ, θ, ψ) . When the D_{ij} inertia matrix components are constructed in this way, forming the D_{ijk} components as Christoffel symbols is to be expressed by partial derivatives of equation (11) :

$$\frac{\delta f(q)}{\delta q_i} = \sum_{l=1}^M \left(\frac{\delta \omega_l(q)}{\delta q_i} \cdot y_l(q) + \omega_l(q) \cdot \frac{\delta y_l(q)}{\delta q_i} \right). \quad (21)$$

The unknown inertia matrix components of equation (2) to be identified are:

$$D_{13}(\theta), \quad D_{22}(\phi), \quad D_{23}(\phi, \theta), \quad D_{33}(\phi, \theta). \quad (22)$$

Based on quadrotor system structure and inertia matrix symmetry the remaining inertia components are known to be:

$$D_{11} = I_x, \quad D_{12} = 0, \quad D_{21} = D_{12}, \quad D_{31} = D_{13}, \quad D_{32} = D_{23}. \quad (23)$$

Based on equation (5) the following Coriolis term matrix components can be calculated by equations (22):

$$\begin{aligned} D_{122} &= -\frac{1}{2} \frac{\delta D_{22}}{\delta \phi}, & D_{123} &= \frac{1}{2} \left(\frac{\delta D_{13}}{\delta \theta} - \frac{\delta D_{23}}{\delta \phi} \right), & D_{322} &= \frac{\delta D_{23}}{\delta \theta}, \\ D_{133} &= -\frac{1}{2} \frac{\delta D_{33}}{\delta \phi}, & D_{223} &= -\frac{1}{2} \frac{\delta D_{33}}{\delta \theta}, & D_{312} &= \frac{1}{2} \left(\frac{\delta D_{23}}{\delta \phi} + \frac{\delta D_{13}}{\delta \theta} \right). \end{aligned} \quad (24)$$

Remaining D_{ijk} components are trivial identities defined by equation (5).

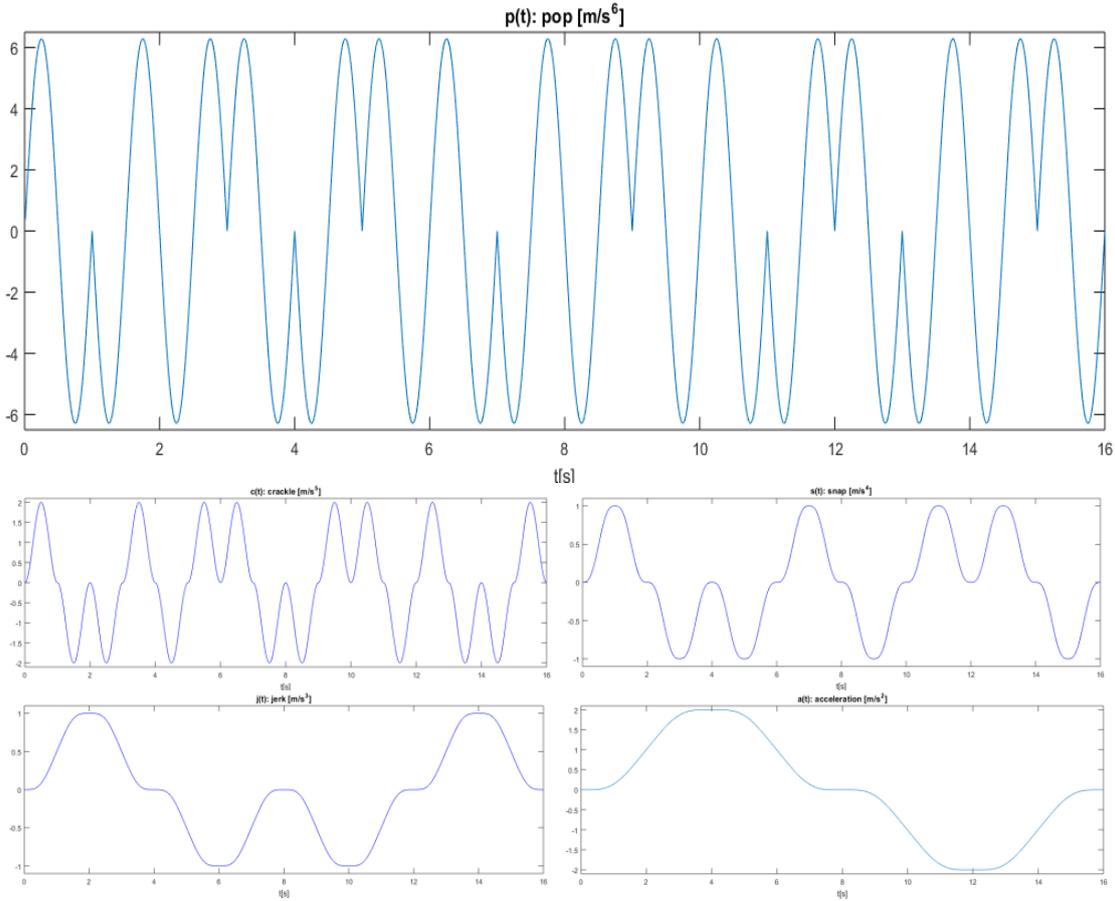


Figure 1. Trajectory pop $p(t)$, crackle $c(t)$, snap $s(t)$, jerk $j(t)$, acceleration $a(t)$, velocity $v(t)$ and displacement $r(t)$.

SIMULATION SETUP AND RESULTS

The proposed method is tested for a quadrotor system simulation from [1] with following parameters: gravity constant $g = 9,81 \text{ m/s}^2$, mass $m = 6 \text{ kg}$, trust factor $k = 121,5 \text{ e}^{-6}$, drag factor $b = 2,7\text{e}^{-6}$, body inertia along axes X, $I_X = 0,6 \text{ kg}\cdot\text{m}^2$, body inertia along axes Y, $I_Y = 0,6 \text{ kg}\cdot\text{m}^2$, body inertia along axes Z, $I_Z = 0,6 \text{ kg}\cdot\text{m}^2$, simulation time $t = 3 \text{ s}$. The training data set is collected from a simulation along a trajectory with jounce for (x,y,z) and ψ defined so that position changes simultaneously along a unit cube main diagonal $(0 \ 0 \ 0)$ - $(1 \ 1 \ 1)$, while performing a full circle rotation in yaw motion 0 - 2π . The simulated resultant torque training data is as presented in Figure 2. The calculated roll, pitch and yaw motions are presented in Figs. 3-5.

Non-linear a_k parameters of the system are identified in a manner that first the input space is normalised to the unit hyper-cube. A set of non-linear parameters consists of six times four a_k integer parameters for defining six fuzzy-partitions of five MFs each, where each partition consists of one z -type MF, three π -type MFs and one s -type MF as in (9)-(18). These six fuzzy-partitions serve as antecedents for the four fuzzy-systems like in equation (11) and (21), used for identifying D_{ij} , with $ij = (13, 22, 23, 33)$ as defined in equations (22)-(24) and (5). Two unknown linear parameters D_{11} and D_{12} of the quadrotor model as in equation (23), together with 170 linear parameters of the four TSK FLSs (2 FLSs with 5 MFs on one input, each rule with 2 c parameters, plus 2 FLSs with 5 MFs on both of the 2 inputs, each rule with 3 c parameters) of equations (22) and equations (24) are determined by the SVD-based LS method as used in [15]. Concluded from equation (17) six fuzzy-partitions (antecedent part of 2 FLSs with 1 input, plus 2 FLSs with 2 inputs are covered by 6 independent fuzzy-partitions) are represented by a vector of six times four a_k parameters, which are optimized by a multi-objective hybrid genetic algorithm as detailed in [16]. Each chromosome evaluation is extended to include an additional round of nonlinear LSQ optimization of a_k parameters. Chromosomes are updated before applying further GA operators, so the GA does not waste time on local optimization; only global search capabilities of the GA are utilized. Three objectives are set for minimization: (1) the root mean square of the torque identification error, (2) the maximum absolute error for any given training data input-output pair, and (3) the condition number of the linear system of equations used for LS calculation of linear parameters. The GA is set to work on a population of 125, divided into 5 subpopulations with migration rate 0,2 taking place after each 5 completed generations. Crossover rate, generation gap and insertion rate is 0,8, selection pressure is 1,5. In each generation 4 % of individuals are subject to mutation, when 1 % of the binary genotype is mutated. Individuals, chromosomes are comprised of 24 Gray-coded integers, each consist of 16 bits. The initial population is set up in a completely random manner. Matrix of the linear equation is pre-processed from equation (3), where FLSs like equation (11) and their partial derivatives like equation (21) are inserted as described in equations (22)-(24). Unknown linear parameters are D_{11} , D_{12} and the 170 c parameters of fuzzy-rule consequents.

Evaluation of each individual is done as follows: (1) Convert the coded a_k values from the chromosome to b_k by equation (18). (2) Evaluate all MFs, which will comprise six fuzzy-partitions from each of six b_k quadruplets by equations (14)-(16). Also evaluate derivatives of equations (14)-(16). (3) The pre-processed matrix of the linear equation is evaluated with the MFs. (4) Linear components of equations (11) and (21) are calculated by SVD decomposition as described in [20]. (5) Next the a_k parameters are fine-tuned by the Matlab "lsqnonlin" function, (6) MFs are re-calculated for the optimised a_k parameters and all linear parameters are re-calculated. (7) Resulting optimised a_k parameters are re-assigned into the chromosome of the evaluated chromosome.

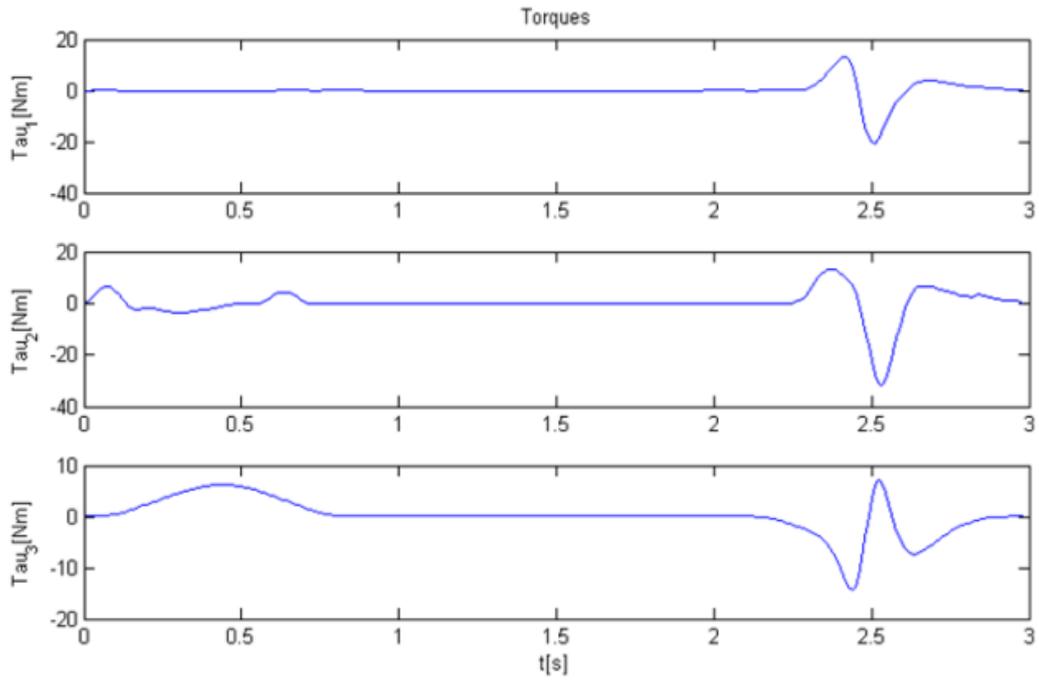


Figure 2. Torque training data set for output.

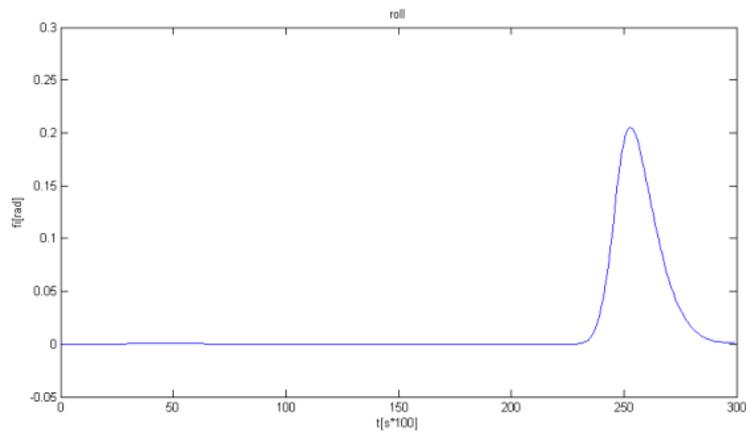


Figure 3. Roll training data for input.

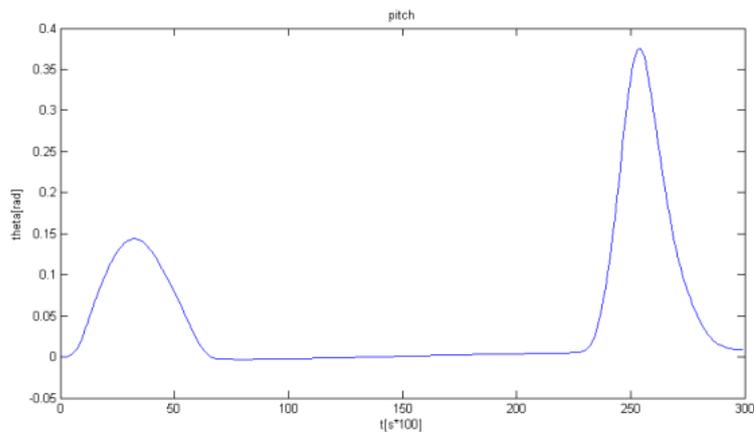


Figure 4. Pitch training data for input.

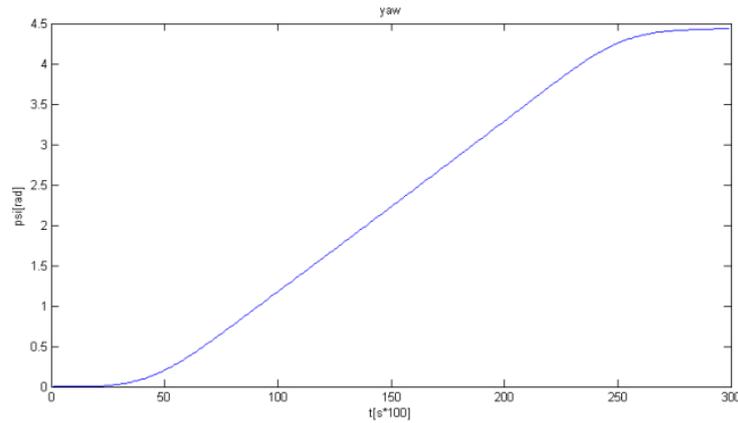


Figure 5. Yaw training data for input.

For the multi-objective rank assignment described in [16], the objective vector is created from: (i) the mean square of the identified torque error, (ii) the maximum absolute torque identification error and (iii) the condition number of the matrix of the linear equation. Stochastic universal sampling is used for selecting the next generation without explicit elitism. To speed up the GA processing, a database of evaluated chromosomes and their objective vectors is created, so only unique new individuals are evaluated in each generation. Convergence is achieved in some 50 generation evaluations, when the mean square error is in order of $5e^{-7}$, the maximum torque error is smaller than 0,005 Nm. For non-dominated chromosomes the condition number of the used matrix of linear equation is in order of $1e^{+38}$. One typical non-dominated chromosome and the corresponding torque identification error are presented on figures 6 to 10. The numerical value of this chromosome is: [61029 8550 10175 18348 6668 22470 11993 57404 608 18024 25310 39946 26698 53573 39807 47476 1909 46 52007 47288 3712 920 50956 5174], which defines fuzzy-partition MF parameters as: b_i for J_{13} : [0,6221, 0,7093, 0,8130]. b_i for J_{22} : [0,0677, 0,2957, 0,4174]. b_i for J_{23} : [0,0072, 0,2221, 0,5238; 0,1593, 0,4791, 0,7167]. b_i for J_{33} : [0,0189, 0,0193, 0,5330; 0,0611, 0,0762, 0,9148].

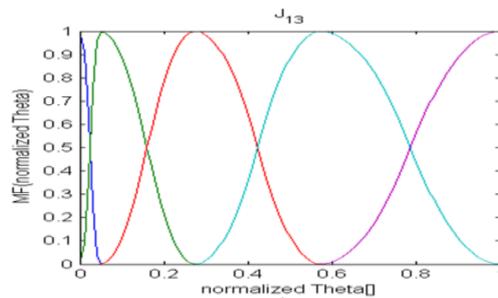


Figure 6. Fuzzy-partition for J_{13} antecedents.

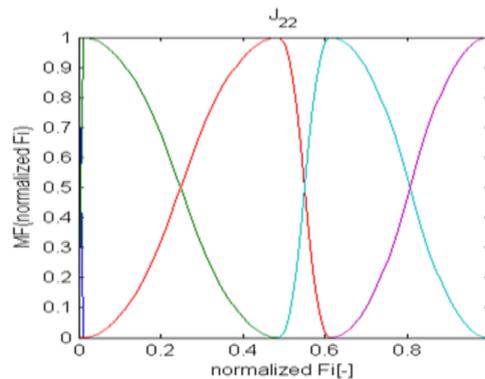


Figure 7. Fuzzy-partition for J_{22} antecedents.

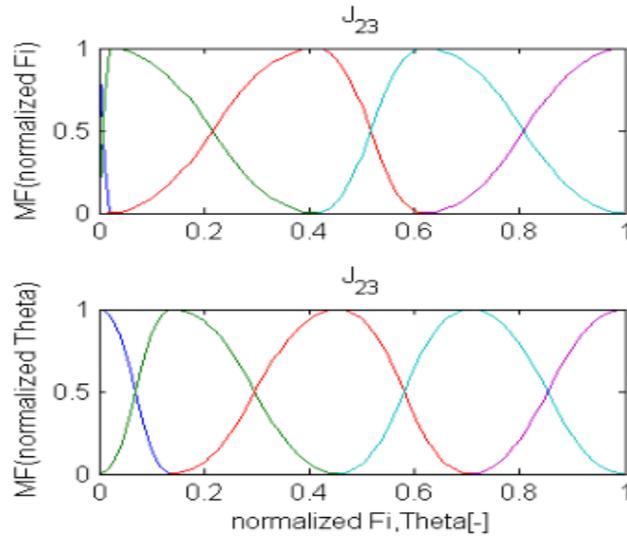


Figure 8. Fuzzy-partition for J_{23} antecedents.

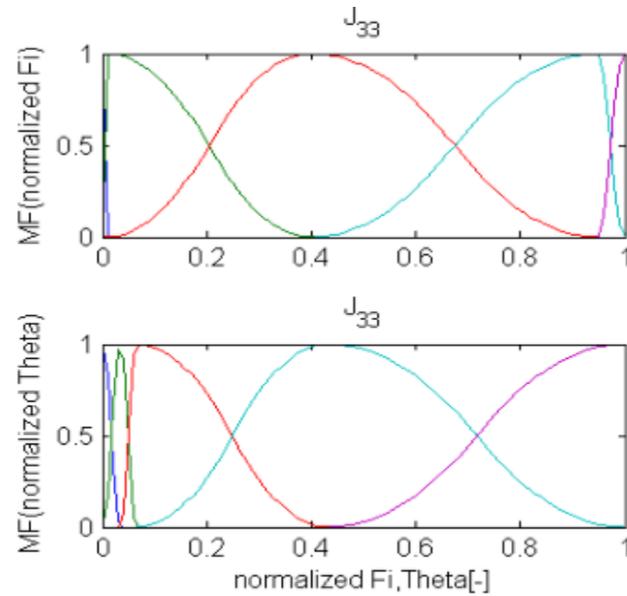


Figure 9. Fuzzy-partition for J_{33} antecedents.

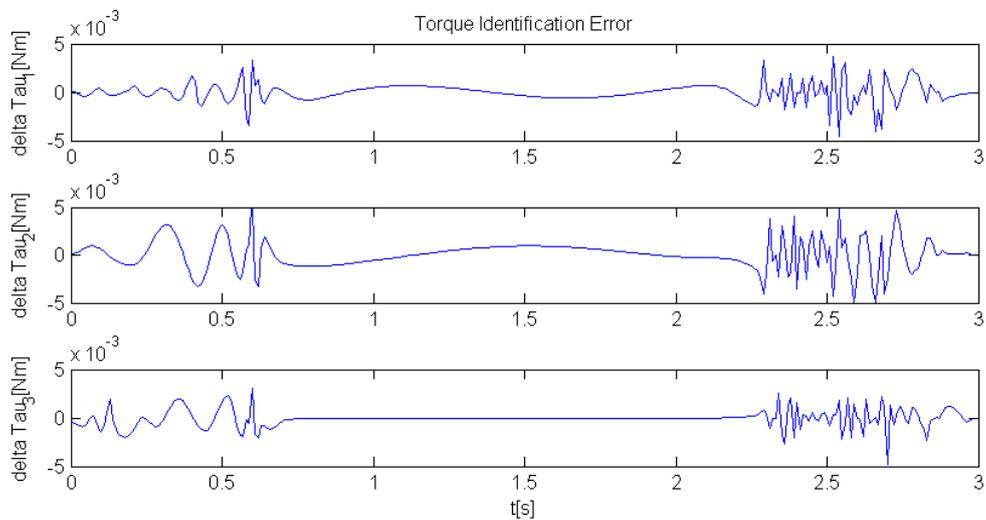


Figure 10. Torque identification error.

CONCLUSIONS

Simulation results of the proposed new quadrotor dynamic model identification method are promising. The quality of identification with the relative torque error being uniformly $<0.1\%$ is excellent, suitable for taking part in a model based control algorithm. The typical condition number for used linear parameter evaluations is very high for the used training data setup, so a more advanced trajectory has to be planned with sufficient inertia excitation along the complete input domain. Also the FLS structure is to be made flexible, in terms that the GA should be able to turn off unnecessary MFs and thus reduce the number of unnecessary rules and linear parameters.

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CONTROL DESIGN FOR UNMANNED AERIAL VEHICLES WITH FOUR ROTORS

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ABSTRACT

Altitude and attitude controlled quadcopter model is used for the behavior and control algorithm testing, before the implementation on the experimental setup. The main objective is the control system design which will achieve good task performance in the combination with the quadcopter dynamic model. Also, for the control model, it is important to be relatively easy to modify for the use of other control algorithms and to be easy to implement on the experimental setup. At the beginning of this article, the control system design process is described. Quadcopter dynamics equations are simplified by applying several assumptions and in that form are used for the controller synthesis. Quadcopter control system is split into inner and outer control loop because the quadcopter is underactuated system which means that the direct control of all of the degrees of freedom is not possible. In the second part, the PI-D control algorithm is described which is applied on the simplified quadcopter dynamic model. The inner loop controls roll, pitch and yaw angles together with the quadcopter altitude. Its outputs are four control variables. Outer loop controls quadcopter X and Y position. Its outputs are roll and pitch desired angles. Regulated quadcopter model behavior is shown for the three types of task. First, the achieving of position in space is simulated. Second, the reference trajectory tracking is shown. Last task shown is the reference trajectory tracking with added periodical disturbances. Simulations show bounded positions error of the regulated quadcopter system using PI-D controller for the different types of tasks performed under different conditions.

KEY WORDS

quadcopter, control design, inner control loop, outer control loop, PI-D controller

CLASSIFICATION

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INTRODUCTION

In order for the quadcopter to be able to execute tasks, control algorithms are needed to be implemented. The goal of the control system design is stabilization of the system state around the desired reference state, or changing that state according to some law, regardless of the inner or outer disturbances. That is achieved with the feedback, which allows comparison of the measured value of the process with the desired one. Prior the control algorithm implementation on the experimental setup, it must be tested in combination with the dynamic model [1].

Quadcopter has six degrees of freedom (6 DOF) and four control variables which means that the quadcopter is underactuated and dynamically unstable system. The only moving parts are the propulsor propellers which are rotating with respect to the fixed propulsor axis. Quadcopter frame has a cross (+) configuration where X_B and Y_B axes go through the propulsors. X_B and Y_B are body coordinate frame axes (body coordinate frame (system) \mathcal{F}^B is fixed to the quadcopter body (frame)). Quadcopter frame is assumed to be a rigid structure. The only variable thing is considered to be the propellers revolutions per minute (RPM) that influence the quadcopter movement.

CONTROL SYSTEM DESIGN

Quadcopter dynamics is derived from the quadcopter dynamic model [2]. The main equations are quadcopter accelerations as functions of the control variables:

$$\ddot{X} = (\cos\psi\sin\theta\cos\phi + \sin\psi\sin\phi) \frac{U_1}{m} \quad (1)$$

$$\ddot{Y} = (\sin\psi\sin\theta\cos\phi - \cos\psi\sin\phi) \frac{U_1}{m} \quad (2)$$

$$\ddot{Z} = -g + (\cos\theta\cos\phi) \frac{U_1}{m} \quad (3)$$

$$\dot{p} = \frac{I_{yy} - I_{zz}}{I_{xx}} qr - \frac{J_{TP}}{I_{xx}} q\Omega + \frac{U_2}{I_{xx}} \quad (4)$$

$$\dot{q} = \frac{I_{zz} - I_{xx}}{I_{yy}} pr + \frac{J_{TP}}{I_{yy}} p\Omega + \frac{U_3}{I_{yy}} \quad (5)$$

$$\dot{r} = \frac{I_{xx} - I_{yy}}{I_{zz}} pq + \frac{U_4}{I_{zz}}, \quad (6)$$

where \ddot{X} , \ddot{Y} , \ddot{Z} are acceleration in the earth fixed coordinate frame (\mathcal{F}^E). ϕ , θ , ψ are roll, pitch and yaw angles with respect to \mathcal{F}^E . U_1 , U_2 , U_3 , U_4 are control variables. m is quadcopter mass, g is gravitational acceleration. I_{xx} , I_{yy} , I_{zz} are moments of inertia with respect to \mathcal{F}^B . J_{TP} is the propulsors rotor and propeller moment of inertia. Ω is overall propeller speed. p , q , r are angular velocities with respect to \mathcal{F}^B , while \dot{p} , \dot{q} , \dot{r} are angular accelerations with respect to \mathcal{F}^B .

Control variables are a function of squared angular velocities of the propellers:

$$U_1 = b(\omega_1^2 + \omega_2^2 + \omega_3^2 + \omega_4^2) \quad (7)$$

$$U_2 = lb(-\omega_2^2 + \omega_4^2) \quad (8)$$

$$U_3 = lb(-\omega_1^2 + \omega_3^2) \quad (9)$$

$$U_4 = d(-\omega_1^2 + \omega_2^2 - \omega_3^2 + \omega_4^2) \quad (10)$$

$$\Omega = -\omega_1 + \omega_2 - \omega_3 + \omega_4, \quad (11)$$

where l is the distance between the quadcopters center of gravity and propulsors axis, b is the thrust coefficient, d is the drag coefficient, ω_i is angular velocity of the propeller i .

The objective of quadcopter stabilization is finding the values of the propellers angular velocities in a way that keeps the quadcopter in desired position and attitude. This is done by the means of the inverse kinematics, i.e. inverse dynamics. Unlike the direct problem, inverse operations are not always possible and are not always unique. Quadcopter dynamics has to be simplified in order to get simple inverse model that can be easy implemented in control algorithms.

Equations (1)-(6) have to be simplified with keeping in mind the following assumptions:

- angular contributions to the accelerations are quite complex because they depend on a couple of parameters, most of which are a vector product of angular velocities. Keeping in mind that the quadcopter movement is near hover state, there are very little changes in angles, therefor those contributions can be ignored.
- angular accelerations are linked with the change of angles with respect to \mathcal{F}^E . They are not equal to the accelerations of the Euler angles in \mathcal{F}^B . Transformation matrix \mathbf{T} defines the relation between the angular velocities with respect to \mathcal{F}^E and the ones in \mathcal{F}^B . Quadcopter movement being close to hovering state, \mathbf{T} is close to the identity matrix, making the angular acceleration equations the same in \mathcal{F}^E and \mathcal{F}^B .
- control algorithm gives the control signals to the propulsors. With four control variables, in a single loop, it is not possible to regulate more than four DOF. Inner loop controls the altitude and attitude, while the outer loop controls quadcopter position by giving the attitude references to the inner loop.

Quadcopter dynamics equations that are used in control synthesis are:

$$\ddot{Z} = -g + (\cos\theta\cos\phi) \frac{U_1}{m} \quad (12)$$

$$\ddot{\phi} = \frac{U_2}{I_{xx}} \quad (13)$$

$$\ddot{\theta} = \frac{U_3}{I_{yy}} \quad (14)$$

$$\ddot{\psi} = \frac{U_4}{I_{zz}}, \quad (15)$$

where $\ddot{\phi}$, $\ddot{\theta}$, $\ddot{\psi}$ are angular acceleration with respect to \mathcal{F}^E .

Control algorithm as inputs has sensor data (or calculated data from the dynamic model) and reference data. Outputs of control algorithm are the angular velocities of four propellers, which can be, through dynamic model, translated to the pulse-width modulation (PWM) signal.

Quadcopter, being an underactuated system, does not allow direct control of all of the DOFs. Control of positions X and Y is achieved indirectly through control of roll and pitch angles in outer control loop. Quadcopter cannot move translationally without the rotation around one of the quadcopter axes. Outer control loop analyses sensor data and desired task data, and its outputs are desired angle values for the inner control loop which then controls the roll, pitch and yaw angles. Inner control loop is the core of the control algorithm. It analyses sensor and outer control loop data together with desired altitude task data. Its outputs are control variables which stabilize the position error through four basic quadcopter movements. From the equations (7)–(10) control variables can be retrieved for the desired accelerations. PI-D controller is used for the desired accelerations assessment.

Inverted movement matrix is used for the calculation of the squared angular propeller velocities for four control variables:

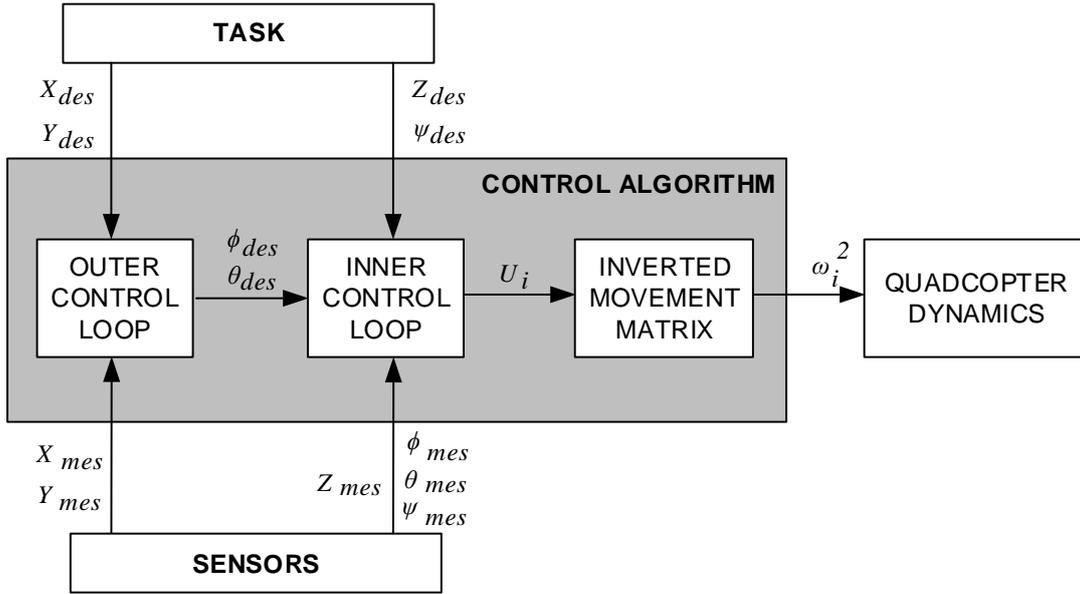


Figure 1. Quadcopter control diagram.

$$\omega_1^2 = \frac{1}{4b} U_1 - \frac{1}{2bl} U_3 - \frac{1}{4d} U_4 \quad (16)$$

$$\omega_2^2 = \frac{1}{4b} U_1 - \frac{1}{2bl} U_2 + \frac{1}{4d} U_4 \quad (17)$$

$$\omega_3^2 = \frac{1}{4b} U_1 + \frac{1}{2bl} U_3 - \frac{1}{4d} U_4 \quad (18)$$

$$\omega_4^2 = \frac{1}{4b} U_1 + \frac{1}{2bl} U_2 + \frac{1}{4d} U_4. \quad (19)$$

PI-D CONTROLLER

Classic PID structure has a derivative term calculated from the error signal, which is a downside of that structure when it comes to the quadcopter control. If the task takes the form of the step function, output of the derivator will be an impulse which could bring the propulsors to the state of saturation and push the system outside of the linear space. That is the reason for the PI-D structure of the controller (Figure 2) in which the derivative term is being calculated from the sensor data.

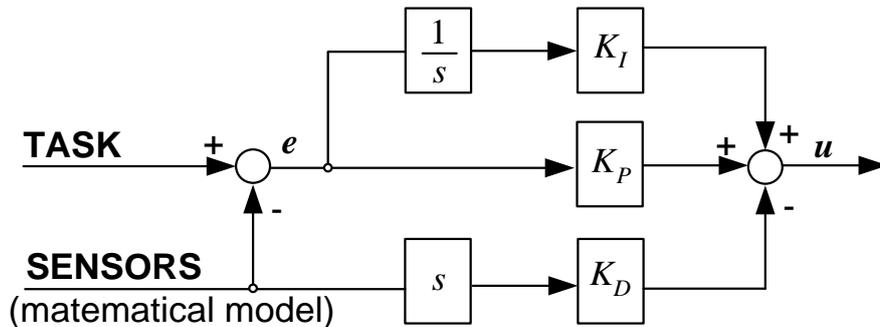


Figure 2. PI-D controller structure.

INNER CONTROL LOOP

Inner control loop controls quadcopter altitude and attitude. Input variables for inner loop can be divided in two parts, task and sensor variables as shown in figure 2. Task variables are desired altitude and yaw angle that are given by the task that quadcopter needs to accomplish and desired roll and pitch angles, that are calculated in the outer control loop. Sensors give measured altitude, roll angle, pitch angle and yaw angle. Inner loop outputs are four control variables.

Altitude control

Equation for the thrust force control variable U_1 is:

$$U_1 = K_{PZ}e_Z + K_{IZ} \int e_Z - K_{DZ}\dot{Z}_{mes} + mg, \quad (20)$$

where K_{PZ} , K_{IZ} and K_{DZ} are three altitude PI-D controller parameters. e_Z is the altitude error, where $e_Z = Z_{des} - Z_{mes}$. Z_{des} is the desired altitude and Z_{mes} is the measured altitude.

Roll control

Equation for the roll moment control variable U_2 is:

$$U_2 = K_{P\phi}e_\phi + K_{I\phi} \int e_\phi - K_{D\phi}\dot{\phi}_{mes}, \quad (21)$$

where $K_{P\phi}$, $K_{I\phi}$ and $K_{D\phi}$ are three roll angle PI-D controller parameters. e_ϕ is the roll angle error, where $e_\phi = \phi_{des} - \phi_{mes}$. ϕ_{des} is the desired roll angle and ϕ_{mes} is the measured roll angle.

Pitch control

Equation for the pitch moment control variable U_3 is:

$$U_3 = K_{P\theta}e_\theta + K_{I\theta} \int e_\theta - K_{D\theta}\dot{\theta}_{mes}. \quad (22)$$

Similar to the roll control, $K_{P\theta}$, $K_{I\theta}$ and $K_{D\theta}$ are three pitch angle PI-D controller parameters. e_θ is the pitch angle error, where $e_\theta = \theta_{des} - \theta_{mes}$. θ_{des} is the desired pitch angle and θ_{mes} is the measured pitch angle.

Yaw control

Equation for the yaw moment control variable U_4 is:

$$U_4 = K_{P\psi}e_\psi + K_{I\psi} \int e_\psi - K_{D\psi}\dot{\psi}_{mes}, \quad (23)$$

where $K_{P\psi}$, $K_{I\psi}$ and $K_{D\psi}$ are three yaw angle PI-D controller parameters. e_ψ is the yaw angle error, where $e_\psi = \psi_{des} - \psi_{mes}$. ψ_{des} is the desired yaw angle and ψ_{mes} is the measured yaw angle.

OUTER CONTROL LOOP

Outer control loop is used because the quadcopter is underactuated system and it is not possible to control all of the quadcopter DOF directly. As said before, the inner loop directly controls 4 DOF, those being three angles and altitude. To be able to indirectly control X_E and Y_E position, outer loop is used. Outer control loop, as its outputs, give desired roll and pitch angles to the inner loop for the desired X_E and Y_E position. Outer control loop is superior to the inner control loop.

Equations (1) and (2) can be singled out which are the equations for the quadcopter X_E and Y_E linear accelerations:

$$\ddot{X} = (\cos\psi\sin\theta\cos\phi + \sin\psi\sin\phi) \frac{U_1}{m} \quad (24)$$

$$\ddot{Y} = (\sin\psi\sin\theta\cos\phi - \cos\psi\sin\phi) \frac{U_1}{m}. \quad (25)$$

Quadcopter dynamics of the X_E and Y_E linear accelerations can be simplified in the similar way as the quadcopter dynamics equations (12) – (15). Again, the quadcopter movement is observed as a hovering state, i.e. roll and pitch angles are very small (close to 0). Keeping that in mind, the equations (24) and (25) can be transformed to:

$$\ddot{X} = (\cos\psi \theta + \sin\psi \phi) \frac{U_1}{m} \quad (26)$$

$$\ddot{Y} = (\sin\psi \theta - \cos\psi \phi) \frac{U_1}{m}. \quad (27)$$

Matrix notation of the equations (26) and (27):

$$\begin{bmatrix} \ddot{X} \\ \ddot{Y} \end{bmatrix} = \frac{U_1}{m} \begin{bmatrix} \sin\psi & \cos\psi \\ -\cos\psi & \sin\psi \end{bmatrix} \begin{bmatrix} \phi \\ \theta \end{bmatrix}. \quad (28)$$

From the equation (28), roll and pitch angles are being calculated. Because of the assumption that the quadcopter movement is near the hovering state, thrust force U_1 has to nullify the gravitational force allowing for the U_1/m to be changed with the gravitational acceleration g .

Equation for the desired roll and pitch angles is:

$$\begin{bmatrix} \phi_{des} \\ \theta_{des} \end{bmatrix} = \frac{1}{g} \begin{bmatrix} \sin\psi & -\cos\psi \\ \cos\psi & \sin\psi \end{bmatrix} \begin{bmatrix} \ddot{X} \\ \ddot{Y} \end{bmatrix}. \quad (29)$$

SIMULATION RESULTS

Behavior of the controlled quadcopter system depends on the dynamic model of the quadcopter and the control algorithm. Control algorithm input values are the values defined in the task as well as the dynamic model outputs. Control algorithm outputs are the four control variables which are also the dynamic model inputs.

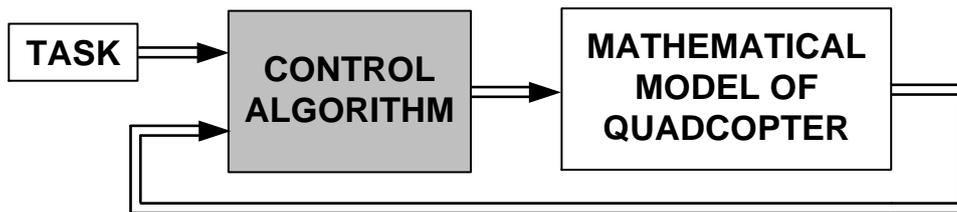


Figure 3. Controlled quadcopter system.

Simulation results are given for the three cases. First case is the simulation of the achieving the desired position. Second case is the reference trajectory tracking and the final case is the reference trajectory tracking with the addition of the periodic disturbance.

ACHIEVING THE DESIRED POSITION

The desired point in space, defined by three coordinates with respect to \mathcal{F}^E , is arbitrarily chosen. The control algorithm is tuned for the quickest desired point achievement. Simulation time is 20 s.

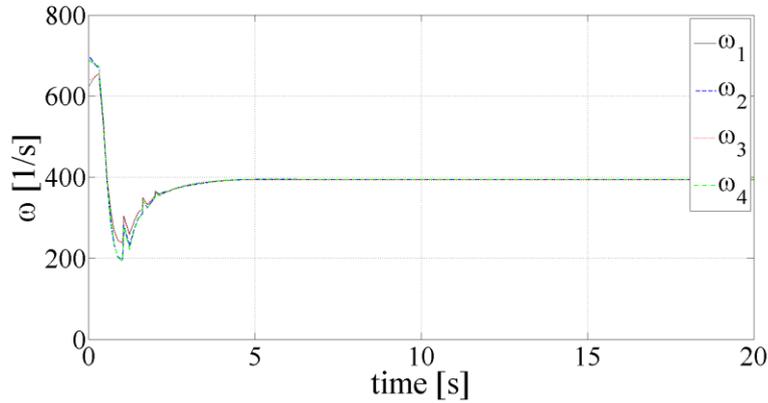


Figure 4. Angular propeller velocities – achieving the desired position in space.

Figure 5 shows the quadcopter attitude which constantly changes until the quadcopter gets to the desired position. After achieving that, roll and pitch angles are 0. Yaw angle is arbitrarily chosen.

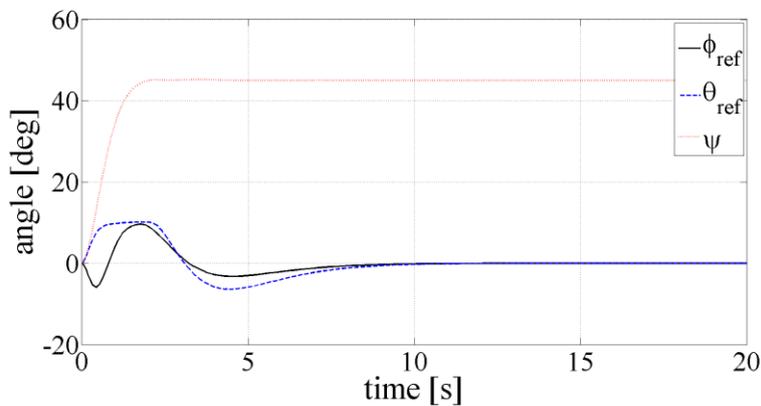


Figure 5. Quadcopter attitude – achieving the desired position in space.

Figure 6 shows that after certain amount of time (cca. 10 sec), depending of the controller parameters, quadcopter reaches the desired position ($X_E = 15, Y_E = 6, Z_E = 10$) and holds that state.

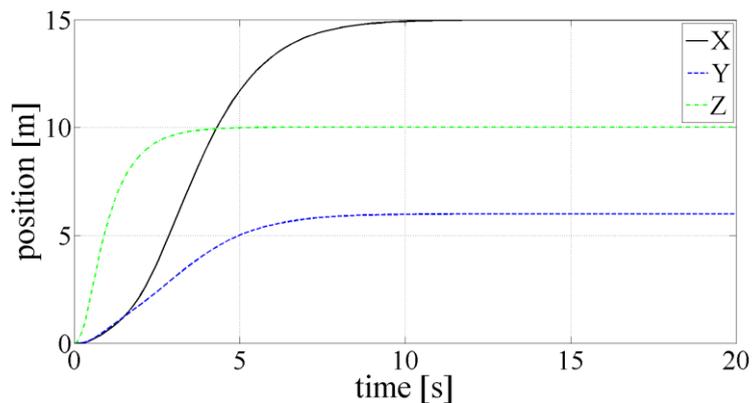


Figure 6. Quadcopter position – achieving the desired position in space.

REFERENCE TRAJECTORY TRACKING

Chosen trajectory is of a helix shape because of the simple generating and displaying. Helix is a combination of three functions, two of which are of sinusoidal shape (X_E and Y_E position), and one is linear (Z_E position). Simulation time is set to 100 s.

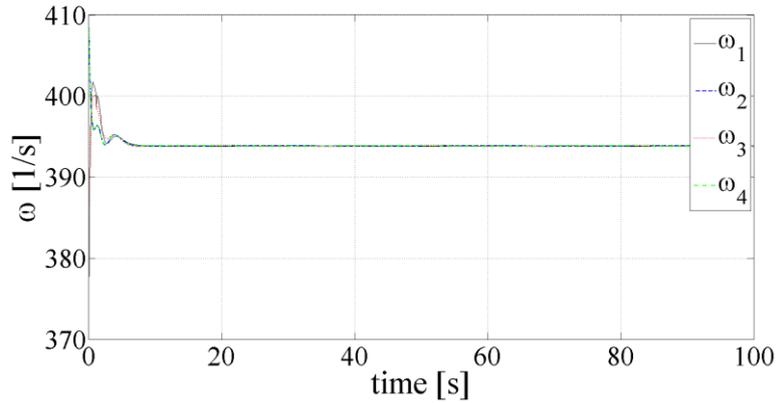


Figure 7. Propeller angular velocities – reference trajectory tracking.

Figure 7 shows propeller angular velocities which depend on the reference trajectory.

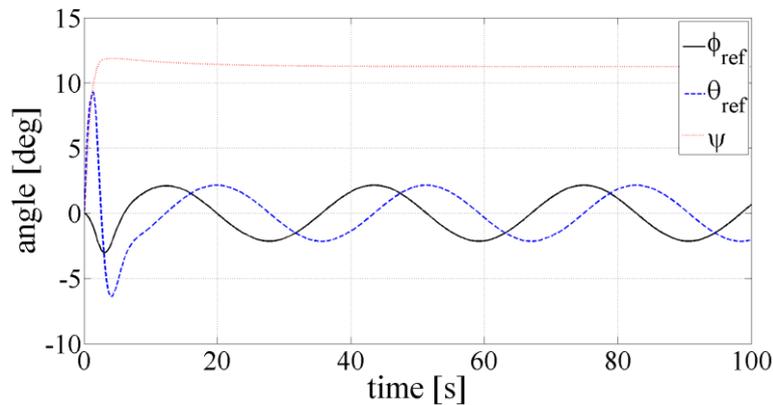


Figure 8. Quadcopter attitude – reference trajectory tracking.

Figure 9 shows that quadcopter quickly gets close to the reference trajectory and that is tracking it with bounded tracking error, being unable to achieve asymptotic error convergence due to the variable reference state.

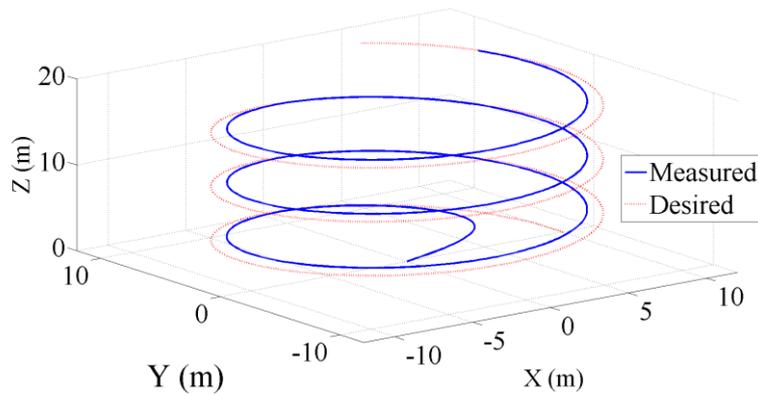


Figure 9. 3D view of reference trajectory tracking.

REFERENCE TRAJECTORY TRACKING WITH ADDED PERIODICAL DISTURBANCES

In this case of trajectory tracking, periodical external force disturbances are added in XY plane. X coordinate disturbance profile have amplitude of 2 N, period of 10 seconds, duration of 0,5 second and phase delay of 8 seconds. Y coordinate disturbance profile have amplitude of 1,5 N, period of 15 seconds, duration of 1 second and phase delay of 6 seconds.

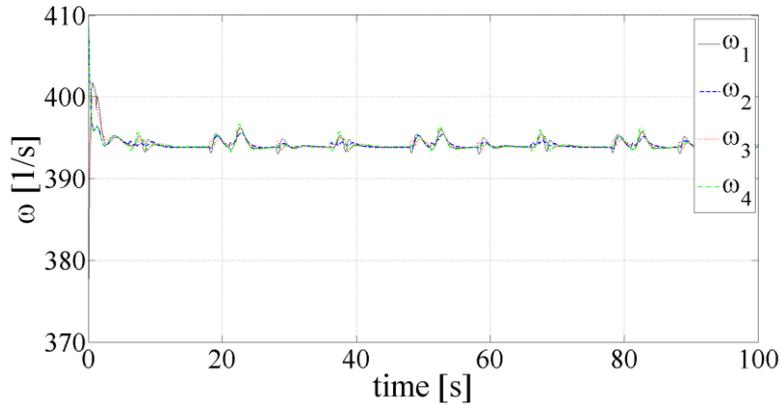


Figure 10. Propeller angular velocities – reference trajectory tracking with added periodical disturbances.

Figure 11 shows changes of angular velocities which depend on the reference trajectory and given periodical disturbances.

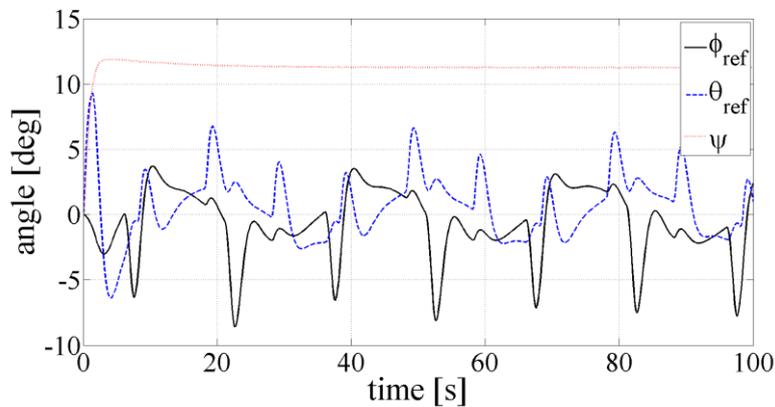


Figure 11. Quadcopter attitude – reference trajectory tracking with added periodical disturbances.

Figure 12 shows quadcopter following the reference trajectory with bounded position error. Disturbances are affecting the quadcopter position and attitude, but in the acceptable boundaries which are not allowing the quadcopter to lose track of the reference trajectory.

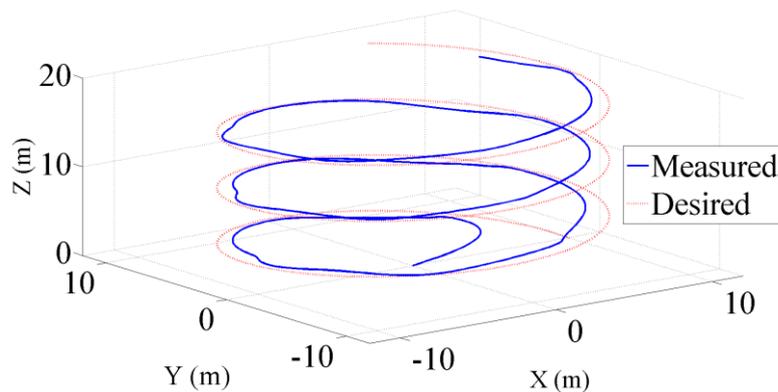


Figure 12. 3D view of reference trajectory tracking with added periodical disturbances.

CONCLUSIONS

This article has shown control design and control algorithm implementation which in the combination with the quadcopter dynamic model form regulated quadcopter system. During

the control design phase, some assumptions were made in order to get simplified quadcopter dynamics equations.

Quadcopter behavior while performing different tasks in different conditions was shown by simulation where some control variables constraints were made with the goal of more realistic description of quadcopter behavior. Controller parameters were chosen empirically.

Outer control loop outputs are inner control loop inputs so the outer loop parameters were chosen in a way that in the combination with the inner loop parameters give the most suitable control variables. Simulation results have shown the stability, robustness and error boundedness of the PI-D controller.

Further work will include control algorithm implementation on the experimental setup. Also, more advanced control algorithms will be tested with the objectives to improve quadcopter system robustness and tracking performances as well as a better energy management.

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THE DEVELOPMENT OF SELF STRUCTURES AND ACTIVE COPING

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ABSTRACT

In addition to cope with usual stressful circumstances at work, nowadays, it is important to examine what kind of mental capacities of medical staff are adaptive in respect of a new type of stress – job insecurity.

Special focus is put upon self structures as personality determinants and the role they have in coping.. The aim of the study was to determine the role of the self structures in active coping with job insecurity. It was supposed that the increasing integration of self structures leads to increasing use of active coping strategies. Perceived job insecurity was measured by The job insecurity perception scale (Knežević and Majstorović, 2013). The Ego Functioning Questionnaire (Majstorović, Legault and Green-Demers, 2008) was used to evaluate types of ego-functioning; coping were assessed by the Cybernetic coping scale (Edwards and Baglioni, 1993).

In order to test the hypothesis the multivariate regression analysis was developed with self-regulation as predictor and active coping strategy as a criterion. A significant model $F(3, 306) = 26,73$, $p < 0,001$, was obtained with all the predictors selected as significant. The prediction directions were as expected - Integrated and Ego-investing self were positive predictors ($\beta = 0,35$, $p < 0,001$, and $\beta = 0,16$, $p < 0,01$, respectively), while the impersonal self singled out as a negative predictor ($\beta = -0,13$, $p < 0,05$). The results have shown that the development of self structures is valid predictor for the active coping of medical staff when facing with job insecurity.

KEY WORDS

self structures, job insecurity, coping

CLASSIFICATION

JEL: Z19

INTRODUCTION

The work of medical staff is extremely stressful; it requires developed mental capacity to overcome everyday stress and to function adaptively in stressful circumstances. Nowadays, it is especially important to examine what kind of mental capacities of health care workers are adaptive in respect of a new type of daily intense stress what is stress caused by rising job insecurity.

JOB INSECURITY

According to Vander Elst et al. [1] job insecurity is defined as frustration of basic psychological needs. Klandermans and van Vuuren [2] state that job insecurity can be seen as objective and subjective construct. Subjective job insecurity represents a psychological phenomenon which is primarily characterized by the experience of uncertainty connected to the employment future where there might be significant differences among the employees within the same organization [3].

The job insecurity is a threat that each individual perceives and responds differently when it reaches a critical level. A great number of situational and individual factors determine the threshold of threat and influence the readiness of an individual to perceive and react to the threat: a type of affective attachment [4], defensive self-respect [5], authenticity and consciousness [6], etc. The perception of job insecurity is also influenced by certain demographic and status variables. The researches have most commonly examined the connection to gender, age, education level, length of work experience and previous experiences with the job insecurity perception [7]. Hodgins and Knee [8] speak about the personality variables that influence the job insecurity observation – first of all, types of self structures and dispositional mood factors.

SELF STRUCTURES AND THREAT

The self represents the personality instance which is responsible for the allocation of conative and cognitive resources which help the individual to establish, up to a specific degree, an integrated experience of the world and himself in it. Hodgins and Knee [8] represent the humanistic conceptualization of the self in accordance with the theory of self-determination, they point out that human beings possess an inherited organismic self, which consists of the main motivational apparatus and cognitive developmental dispositions. The developmental process is initiated by three basic psychological needs: the need for relatedness, competence and autonomy. However, the social surroundings can encourage or obstruct the natural tendency of the self to accomplish its potential completely. According to these authors, the quality of the ego functioning becomes directly dependent on how successfully the system integrates outer and inner experiences into existing structures. It also becomes dependent on the adaptability of structures in situations when they are faced with new upcoming experiences (primarily of a threatening character).

Beginning from the motivational orientation and the dominance of some of the personal self-regulation styles (the autonomous, the controlled and the impersonal). Hodgins and Knee [8] describe three types of the self: the integrated self, the ego-investing an impersonal self, which influence the perception and the processing of unpleasant experiences. The integrated self refers to the harmonized self system; it originates in individuals who got required social support in their efforts to satisfy completely their three basic psychological needs during their development. Individuals with an integrated self succeed in learning to value themselves and what they really are, to recognize the importance of their own authentic inner impulses and develop unconditional self-evaluation and self-respect. While conducting most of their

activities these individuals are intrinsically motivated; they have stable self-confidence, they enjoy social contacts and they are spontaneous in their reactions. Their self-system is open to changes and innovations and it is ready for research and for receiving contents experimentally from both, the inner and outer reality. With regard to other ego functioning types, the integrated self gives the opportunity for a more objective and more timely perception. Hodgins and Kneee [8] point out that the ego-investing self develops within circumstances where autonomy lacks support. When this happens, the internalized social pressure and limitations stimulate the development of self-evaluation based on a constructed (fake) image about oneself, which is founded on acquiring approval of others instead of authentic self-affirmation. As a result of this, individuals are energetically encouraged by extrinsic goals, like money, fame and power; they behave rigidly, their perception of reality is selective and they are eager to gain confirmation and acknowledgement for their actions and behavior. The impersonal self represents the lowest level of self-integration. This type of self appears during the individual's development and it includes personal experience in which three basic physiological needs were in a great way (critically) unsatisfied [8]. The vitality of these individuals is low and it points out to the common lack of motivation. These individuals display lack of intention in reacting, and when they show it, they have a wish to terminate the action as fast as possible; they get excited easily, they are often cluttered with information and overwhelmed by negative thoughts and feelings. As a consequence of this, these individuals withdraw from new experiences, they turn towards routines and repetitive activities and they get engaged in social auto-isolation in order to protect their own unstable functioning.

Given the situation of job insecurity requires effective self-regulatory processes that enable a high level of directivity of attention and regulation of cognitive effort, careful self-reflection, monitoring and evaluation of implemented efforts and action, it is supposed that only good self-regulatory processes and developed self structures exhibit the potential to successfully operate and to active cope in a stressful circumstance like job insecurity. In this direction, the aim of this study is to determine the role of the self structures in active coping with job insecurity. It was supposed that the increasing integration of self structures leads to increasing use of active coping strategies in situation of job insecurity.

METHOD

SAMPLE

The research has been conducted on a sample of 102 health workers: men (46; 45,1 %), and women (56; 54,9 %), from the three public hospitals in the Autonomous Province of Vojvodina. Research was conducted in the period January-March 2013.

INSTRUMENTS

The Scale of the Perception of Job Insecurity (SPJI) [9] was created according to similar scales [10]. The scale consists of 22 items, all of the items are expressed in Likert's scale of five degrees. The perception of job insecurity was conceptualized as the accessibility of the working role for the employees for the certain time in the future, and it is made of three qualitative dimensions: the feeling of helplessness (affective dimension), the strength of the threats (affective) and the valuation of the possible job loss (cognitive dimension).

The Ego Functioning Questionnaire [11] was designed to measure three types of self: Integrated self, Egoinvesting self and Impersonal [8]. The questionnaire consists of 30 items that measure different types of self (10 items for each type of the self). All items are expressed on the seven-point Likert scale.

The coping concept in the article is placed within the framework of cybernetic theory of stress and coping formulated by Edwards [12] according to which coping is conceptualized as an attempt to reduce and eliminate negative effects of stress on psychological well – being of an individual. Following coping behaviours (five forms) were assessed by the *Cybernetic coping scale* [13]: (a) attempts to reduce symptoms, and to directly improve the psychological well-being (b) change in the situation – an active troubleshooting by trying to bring the situation in conjunction with personal preferences, (c) customization – customize personal preferences to fit the situation (d) overcome by devaluing the importance for the individual – importance that is generated from a disagreement between his desires and perceptions, and (e) avoiding – divert attention from the situation. According to Edwards [12], of these five coping strategies, the only active strategy is Change in the situation.

METHOD OF DATA ANALYZING

The descriptive statistics, as one of the statistics analysis, and multiple regressive analyses were used. Table 1 shows the descriptive indicators of dependent variables in research.

Table 1. Descriptive indicators of dependent variables ($N = 102$).

| Performance | Achieved range | AS | SD | α | The curvature distribution | The ellipticity distribution |
|-------------------------------|----------------|-------|-------|----------|----------------------------|------------------------------|
| Change in the situation (4) | 4-16 | 11,59 | 2,65 | 0,79 | 0,24 | 0,48 |
| Customization (4) | 5-16 | 10,27 | 2,19 | 0,64 | 0,24 | 0,48 |
| Devaluing (4) | 4-15 | 8,48 | 2,94 | 0,86 | 0,24 | 0,48 |
| Avoiding (4) | 4-16 | 8,21 | 3,06 | 0,85 | 0,24 | 0,48 |
| Reduce of symptoms (4) | 4-16 | 10,29 | 2,82 | 0,82 | 0,24 | 0,48 |
| Perceived job insecurity (21) | 35-105 | 73,93 | 16,80 | 0,90 | 0,26 | 0,51 |
| Integrated self (10) | 26-70 | 50,54 | 9,50 | 0,83 | 0,24 | 0,48 |
| Egoinvesting self (10) | 22-66 | 43,49 | 10,18 | 0,81 | 0,24 | 0,48 |
| Impersonal self (10) | 10-51 | 25,58 | 11,10 | 0,89 | 0,24 | 0,48 |

After analysis, it is evident that from the normal distribution does not significantly differ not one variable (as seen from the index of curvature and kurtosis distribution, which are located within the values -1 and $+1$), and the reliability below the lower limit on eligibility ($0,70$) has the subscale Customization on CCS instrument. Other scales have satisfactory reliability indices.

RESULTS

To test this hypothesis the multivariate regression analysis was conducted with three types of self-regulation as predictors (Integrated self, Egoinvesting self and Impersonal self) and one active coping strategy (Change in the situation) as a criterion. When predicting the strategy Change in the situation a significant model $F(3, 306) = 26,73, p < 0,001$, is obtained with all the predictors selected as significant, as shown in Table 2.

The resulting prediction directions are as expected – Integrated and Egoinvesting self are positive predictors ($\beta = 0,35, p < 0,001$, and $\beta = 0,16, p < 0,01$, respectively), while the Impersonal self singled out as a negative predictor ($\beta = -0,13, p < 0,05$) of Change in the situation.

Since the integrated self structures (Integrated and Egoinvesting self) encourage active coping and undeveloped (Impersonal self) are not associated with an active coping of medical staff in unstable employment situation, we can say that the formulated hypothesis is supported.

Table 2. The significance of the model and partial contributions of predictors in the prediction of Change in the situation.

| Model | Predictors | β | t | p |
|---|-------------------|---------|--------|-------|
| $R^2 = 0,21$; $F = 26,73$; $p < 0,001$ | Integrated self | 0,349 | 6,182 | 0,000 |
| | Egoinvesting self | 0,159 | 2,779 | 0,006 |
| | Impersonal self | -0,125 | -2,380 | 0,018 |

DISCUSSION

Results of multivariate regression suggest a statistically significant positive relationship between integrated self-regulation and the use of change in the situation and egoinvesting self-structures and the use of active coping strategies – change in the situation. impersonal self-regulation is a negative predictor of strategy change in the situation.

Different types of self structures generate different levels of self-confidence, vulnerability and tolerance towards threat (threshold of threat) conditioning by this the level of a person's defense and his openness to the current experience. The integrated self enables a completely authentic perception and processing of an unpleasant experience – such as it really is with full self-confidence directed towards overcoming of threat, while the highest level of defense (the impersonal self) leads to greatest reality distortions, withdrawal, avoidance and similar. These self structure characteristics determine the manner and level of activity in relation to the threat. It could be said that the development of self structures and increased integration of self-regulation encourages the active relationship towards stress in the situation of job insecurity and active coping with the intention of establishing control over the situation.

Taking into account the differences in the quality and quantity of self structures and self-regulatory processes, as well as the type of motivational orientation that lies at their basis, it can be assumed that integrated self in a situation of job instability will be directed towards action that implies the realization of personal target of authentic value. Implementation of the strategy change in the situation will be aimed at trying to minimize the risks associated with job instability, and the threat generated by job insecurity will be transformed in a challenge that calls for direct action. In contrast to the integrated self, egoinvesting self does not provide a good structure target, nor a sense of personal ownership and has no capacity for strategic planning, and is reactive, not proactive by character. Due to a lower quality of self-regulatory process, egoinvesting self-regulation lacks basic information and goals within specific, operational self-process, and relies on social comparison that is used for the evaluation of outcomes. Active coping implemented by egoinvesting self structures will be directed towards restoring impaired psychological well-being and repairing damage of the self caused by job insecurity. Therefore, both types of self-developed structures shall encourage active coping – change in the situation – active coping of integrated self will be directly aimed towards the preservation of work and reduction of the risks associated with the job instability, active coping of egoinvesting self will be indirectly aimed at restoring the psychological well-being of the individual in a situation of job insecurity.

The other research results also show that good quality of self regulation is a positive predictor, and poor quality of self structures is negative predictors of the problem-focused coping strategies [14]. Also, it was confirmed that the self-developed structure is positively associated with active forms of overcoming [15]. Identified regulation which is base of

integrated self allows a person to be persistent in achieving the goals that are important to her in the long run; it encourages the person to be persistent and to foster activities that are not her actual interest, but which are important in achieving her goal [14], it is associated with positive outcomes in an academic setting, such as, commitment, psychological adjustment to school, perseverance and concentration [15]. In similar way, Blascovich and Tomaka [16] point out that negative excitement that accompanies response to the threat – which is characteristic of the impersonal and partly for egoinvesting self, reduces the capacity for coping.

CONCLUSION

The aim of this study was to determine the role of the self structures in active coping with job insecurity. The results have shown that the increasing integration of self structures leads to increasing use of active coping strategy – change in the situation.

The most integrated self structure (integrated self) show the potential for the highest level of active coping with the situation of unstable job. These structures have the ability to directly confront the stressor – for them, job instability is the challenge. The less integrated self structures (egoinvesting self) indicate the potential for a lower level of active coping – they have the ability to confront the stressor indirectly through rebuilding the damage that occurred at the level of personality in a stressful transaction with unstable job.

The research results increase the insight in the phenomenon of job instability and offer a basis for creating organizational interventions aimed at strengthening resilience of medical staff to stress caused by the perception of job insecurity. Knowing the role of self structures as personality determinants in coping with the job insecurity threat it is possible to create organizational interventions directed towards the resilience of the employees. Taking into account that support from social surroundings influences the nature of the self structures [8], by supporting the social context, conditions will be created for the self to develop openness towards experience and to realize an autonomous regulation of behavior. In other words, the support from the social surroundings will influence the nature of the self functioning so that it will direct it and make it more or less open to new life experiences, or more or less self-determined and active in behavior regulation.

Limitation of research are connected with the structure of the coping process. Due to the fact that job insecurity represents an intense chronic stress with coping mechanisms that vary through the stressful transaction, individual assessment is related to a (separate) specific stressful episode and a coping mechanism that is currently used in this episode. In the study of stress is very important which part of the process is "caught" by research; optimal situation would mean that all research subjects correspond / estimate the same stressful episode in the experience of job instability and the stress of the same degree (magnitude). One way of overcoming the difficulties of this kind is certainly the application of a longitudinal research design in the research.

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CURRENT USAGE OF COMPONENT BASED PRINCIPLES FOR DEVELOPING WEB APPLICATIONS WITH FRAMEWORKS: A LITERATURE REVIEW

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ABSTRACT

Component based software development has become a very popular paradigm in many software engineering branches. In the early phase of Web 2.0 appearance, it was also popular for web application development. From the analyzed papers, between this period and today, use of component based techniques for web application development was somewhat slowed down, however, the recent development indicates a comeback. Most of all it is apparent with W3C's component web working group. In this article we want to investigate the current state of web application development with component approach. Most of all we are interested in which way components are used, which web development frameworks are being used, for which domains is component based web development most popular and successful, etc. How many current web development frameworks explicitly refer to component-based approach? To answer this question, we performed a literature review.

KEY WORDS

component based development, CBD, Web application, WWW, Frameworks

CLASSIFICATION

ACM: H.1.2, H.3.4., H.4.m

JEL: L86

INTRODUCTION

Creating complex software architecture by (re-) using smaller, more manageable, software elements is the main goal of component based development (CBD). In many cases it has proven to simplify software design and have a positive impact on extra-functional properties of software products, e.g. better maintainability, scalability, reliability, usability, etc. Since the research on World Wide Web related development is constantly growing, we find interesting to verify in which way are these two research areas are related. To satisfy our curiosity we conducted a *literature review* in which we analyzed how web researchers and practitioners apply existing component based development techniques to create architecture of their web applications. Since most of the web applications are currently developed using different web development frameworks, we are also interested how many frameworks are based on CBD. Therefore, the main research question is: “*How many of the current web application development frameworks explicitly refer to application of component-based approach?*” – Based on this question we derive several more specific questions:

- Q₁ – In which way is CBD used for web application development?
- Q₂ – What is the relation between CBD and web application development?
- Q₃ – Which component models are used for web application development?
- Q₄ – In which web application development domains is CBD used?

The rest of the article is organized as follows: in Section 2 describes the review protocol and all the related methods used to perform a literature review. Section 3 provides an overview of the paper selection process. In Section 4 we present a detailed analysis of the results and discuss them. Finally, Section 5 concludes the article.

REVIEW PROTOCOL

The review protocol of this study is based on the work of Breivold et.al. [1] and suggestions by Kitchenham [2]. It consists of the following steps (Figure 1): a) motivation statement, b) research goal statement, c) defining the search terms, d) providing information on restrictions and selection criteria, e) database selection, f) paper search process, g) paper quality assessment, h) paper data extraction, i) data synthesis. Since steps a) and b) are given in the previous section, here we proceed with steps c) – e) which are given in the Table 1.

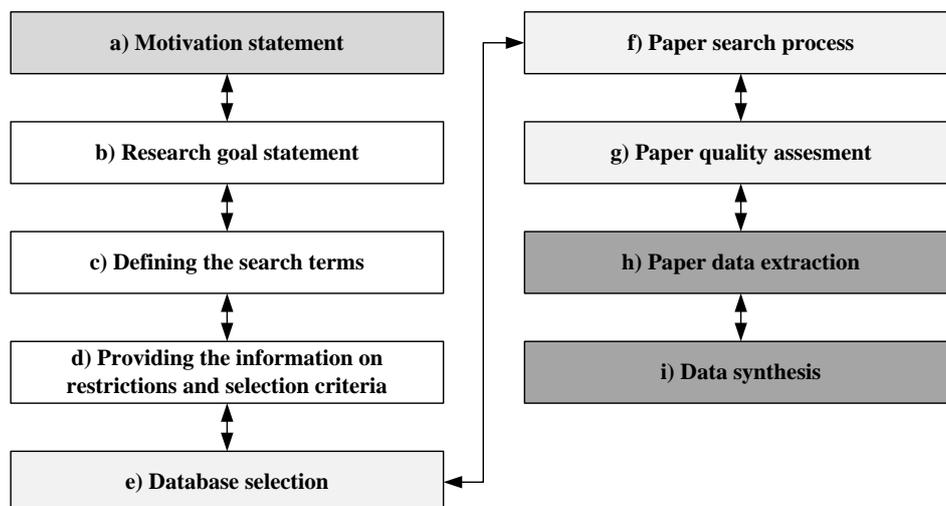


Figure 1. Overview protocol.

SEARCH TERMS, SELECTION CRITERIA AND DATABASE SELECTION

For more effective selection of relevant papers we used Mendeley, a reference management tool [3]. Every database listed in Table 1 provides a way to extract and import the search results into such tools. Since ACM is an exception, we imported the search results manually. Duplicated were automatically excluded or merged.

To additionally ensure that the quality of the papers is satisfactory, there are some additional criteria [1]: a) paper must provide evidence for claims and theoretical reasoning in data analysis, b) paper must have the description of the context in which the study was conducted, c) the research method must be described or easily inferred, and finally d) goals of the study need to be described or easily inferred.

Table 1. Literature review protocol steps c)-e).

| Search terms (using OR operator) | Databases | Restrictions |
|---|--------------------------------------|--|
| <i>“component based” and web and development</i> | SCOPUS ACM Digital | Papers that are included are from 2004 to 2014 (including papers that are in the databases at 15 January 2014) |
| <i>“component based” and web and architecture</i> | Library IEEE Xplore | Papers that are written in English |
| <i>“component-based” and web and development</i> | Science Direct ISI Web of Science | Only full papers are considered |
| <i>“component-based” and web and architecture</i> | | No duplicates should be included |
| <i>“CBD” and web and development</i> | | Peer-reviewed papers in journals, conferences and workshops |
| <i>“CBD” and web and architecture</i> | | Only studies that explicitly refer to use component based approach in web application development |
| | | Only studies that explicitly refer to using or making a framework |
| | | Search process & quality assessment |

DATA EXTRACTION

Once the final list of papers was obtained, a content analysis and review was performed while considering [1]:

- (a) general paper information (title, authors, publication year, source, publication type, citation information, research methodology, and data analysis type) and
- (b) content related information (research focus, area of CBD application, applied CBD models, software application domain (what kind of software, who uses it, etc.), programming languages used, problems with applying CBD, area of future work).

The result of reading the papers are synthesized in the following sections.

SEARCH OVERVIEW

DOMAIN SPECIFIC REVIEW CRITERIA

Based on the research area we decided to exclude papers which refer to service oriented architecture (SOA), semantic web and ontology and finally papers which refer to service oriented computing (SOC).

Since the search terms resulted in 166 papers related. Also, as stated by Bano and Ikram, SOA is a shift of paradigm in software development, as it can be seen in application of web services instead of using commercial off-the-shelf software [4]. Having this in mind we decided to exclude SOA related papers as a whole new literature review can be performed with SOA as a main topic.

Semantic web and ontology related papers are also removed because these principles are used for all kind of applications, not necessarily web applications. Although, some papers corresponded to the initial criteria, we decided to leave out ones which relate to semantic web, as this research area is growing and very specific.

Finally papers which refer to service oriented development, service oriented computing, web-service based applications and development of web-services were left out as they are mostly related to development techniques and SOA. We conclude that similarly as for SOA, this research area would deserve its own separate literature review.

Since some papers are excluded in this phase because they are out of scope, they will not be addressed further. However, we would like to refer the interested readers to the sources: [5-8].

DATABASE QUERIES AND SEARCH RESULTS OVERVIEW

Table 2 shows the overview of the search results. By applying the exclusion criteria from the initial result of 1132 papers only 29 were selected for full reading.

At this point we also verified the validity of research queries. We performed a search without “CBD” term, as presented in Table 2. One can notice that there is no significant difference when this term is left out and “component-based” is used. Finally, by using the terms “component” or “components” alone 7696 results were found in Scopus only. One can easily

Table 2. Search overview.

| Database | Findings without CBD keyword | Findings without restrictions (Language, Year) with “CBD” keyword | 2004 - 2014 | Only English |
|--|-------------------------------------|--|--------------------|---------------------|
| Scopus | 677 | 691 | 567 | 548 |
| ACM | 291 | 296 | 211 | 211 |
| IEEE | 325 | 326 | 240 | 240 |
| Science Direct | 33 | 34 | 24 | 24 |
| Web Of Science | 141 | 146 | 109 | 109 |
| Total | <i>1467</i> | <i>1493</i> | 1151 | 1132 |
| <i>After removing of all duplicates, Mendeley automatically</i> | | | | 761 |
| <i>After removing of all duplicates, Mendeley “Detect Duplicates” option</i> | | | | 733 |
| <i>After removing of covers (journal, conference proceedings covers)</i> | | | | 621 |
| <i>After removing all duplicates, found manually by reading titles and abstracts</i> | | | | 610 |
| <i>After removing all unrelated papers, found manually by reading titles and abstracts</i> | | | | 116 |
| <i>After second reading of abstracts and titles</i> | | | | 106 |
| <i>After removing all papers which do not explicitly refer to application of a framework (reading introduction and conclusion)</i> | | | | 33 |
| <i>After the second complete reading of all papers</i> | | | | 27 |
| <i>Number of papers which are accessible (full text of 3 papers wasn't found in any database)</i> | | | | 24 |

conclude that this terms cannot be used by themselves and considering only the keywords the following query was used:

TITLE-ABS-KEY((web AND development) OR (web AND architecture)) AND TITLE-ABS-KEY(“component based” OR “component-based” OR “component” OR “components”)

The exact search queries with all the restrictions are available in Appendix A of this paper. Appendix B contains the list of final 29 papers labeled [A1] – [A29].

From the final 29 papers which were selected for full reading, 3 of them could not be accessed for full reading. These papers are [A1]-[A3] and because they were unavailable, they are not present in all parts of this review. Also, after all the papers were fully read, two additional ones were excluded which left as with final 24 papers [A4]-[A27]. The two excluded papers are out of scope. Paper [A28] is related to quality assessment and not web development while paper [A29] is business oriented, but mentions frameworks.

RESULT ANALYSIS

DATABASES AND YEAR DISPERSION

As it can be seen by the right data bar in Figure 2, considering the number of papers found, Scopus is the most inclusive database with 22 of final 24 papers (and with 7 found only in Scopus), while Science Direct was the most exclusive with only 1 paper. The remaining two papers not found in Scopus, first was found only in IEEE [A23], while the second one [A20] was in ACM and Web of Science. The number of papers included in the database which were selected for final reading (the original 27 papers, which includes 3 inaccessible) is shown on the left data bar. Here, Scopus was also the most inclusive database with 25 of 27 papers. The two missing papers are the same as previously and both of them are found in IEEE Xplore. Therefore, combining Scopus and IEEE Xplore gives most of the relevant papers in this research area.

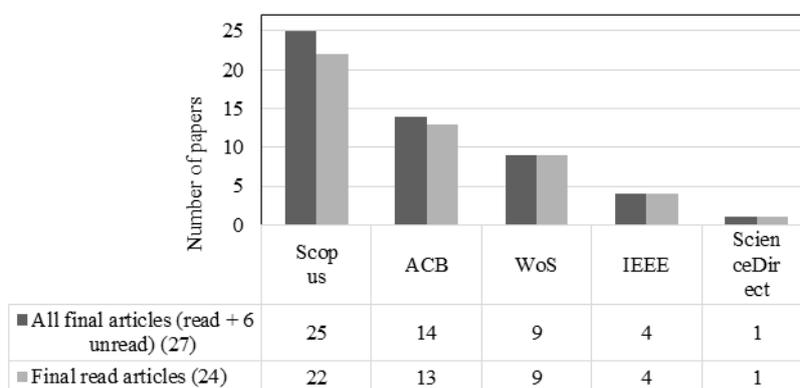


Figure 2. Papers in database.

The database search was performed in mid-January of 2014 and it was set to include papers from previous 10 years, i.e. 2004-2014. Figure 3 shows the dispersion of papers between years. As it can be seen, most of the papers, i.e. around 50% of them, were written between 2005 and 2006. This should be a consequence of Web 2.0 which was popularized by Tim O’Reilly in late 2004 at the O’Reilly Media Web 2.0 conference. At that time there was an increase of web application development and since web applications started growing more complex, it was necessary to ease the development process and perform research in this direction. The solution was found in web development frameworks and component based techniques (as one of the options). Earlier papers are focusing on theoretical aspects while later on they became more practical providing different benchmarks and case studies.

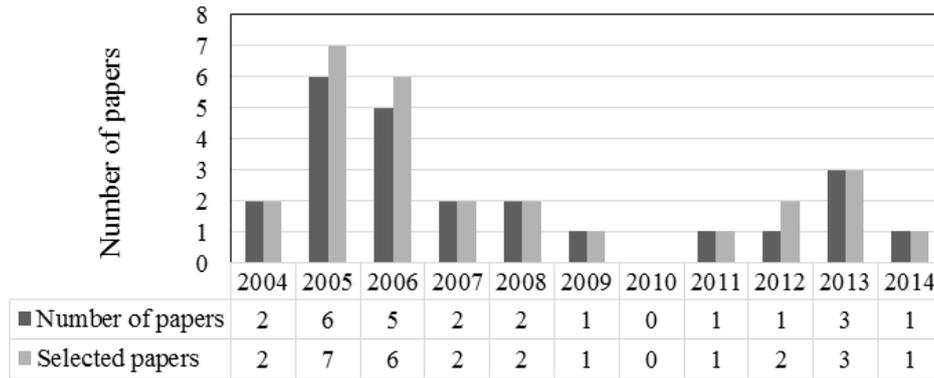


Figure 3. Papers per year.

PUBLICATION TYPES

Figure 4 shows publication types. Two-thirds of selected papers are conference proceedings while one-third of remaining papers were published in journals. List of conference proceedings and journals is presented in Table 3 and Table 4.



Figure 4. Papers per publishing type.

It is interesting to notice that every paper which was selected comes from a different journal and therefore there isn't any conclusion on which journals to follow for this particular topic. However, the conferences are a bit more conclusive. Table 3 shows that two papers come from 13th International WWW Conference Proceedings 2005 while 6 papers are published in Springer's Lecture Notes. This indicates that Springer database should also be included in future investigation of this area.

Table 3. List of journals.

JOURNALS

- 1 Journal of Shanghai University
 - 2 Computer Science - Research and Development
 - 3 Cartographica
 - 4 IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)
 - 5 Journal of Intelligent Information Systems
 - 6 Decision Support Systems
 - 7 Digital Creativity
 - 8 International Journal of Computer Integrated Manufacturing
- JOURNALS OF PAPERS THAT WERE NOT READ IN FULL**
- 9 Advanced Materials Research

Table 4. List of conference proceedings.

| | CONFERENCE PROCEEDINGS | PUBLISHER |
|--|---|------------------|
| 1 | Thirteenth International World Wide Web Conference Proceedings, WWW2004 | ACM |
| 2 | Lecture Notes in Computer Science | Springer |
| 3 | Proceedings - International Conference on Next Generation Web Services Practices, NWeSP 2005 | IEEE |
| 4 | Web3D Symposium Proceedings | ACM |
| 5 | Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining | ACM |
| 6 | Proceedings of the ACM Symposium on Applied Computing | ACM |
| 7 | Lecture Notes in Computer Science | Springer |
| 8 | Lecture Notes in Engineering and Computer Science | Springer |
| 9 | Thirteenth International World Wide Web Conference Proceedings, WWW2004 | ACM |
| 10 | Software Engineering and Advanced Applications, 2005. 31st EUROMICRO Conference | IEEE |
| 11 | Lecture Notes in Computer Science | Springer |
| 12 | ENASE 2013 - Proceedings of the 8th International Conference on Evaluation of Novel Approaches to Software Engineering | Springer |
| 13 | 2008 34th Euromicro Conference Software Engineering and Advanced Applications | IEEE |
| 14 | Lecture Notes in Computer Science | Springer |
| 15 | 5th IEEE/ACIS International Conference on Computer and Information Science and 1st IEEE/ACIS International Workshop on Component-Based Software Engineering, Software Architecture and Reuse (ICIS-COMSAR'06) | IEEE |
| CONFERENCE PROCEEDINGS OF PAPERS THAT WERE NOT READ IN FULL | | |
| 16 | Proceedings of the IASTED International Conference on Internet and Multimedia Systems and Applications | IASTED |
| 17 | ICEIS 2005 - Proceedings of the 7th International Conference on Enterprise Information Systems | ICEIS |

RESEARCH METHODS AND TYPES

Figure 5 presents the information about most common research methods used. In 5 papers authors explicitly state that they are performing a case study while in other papers, the applied research method was inferred from the context. It turns out that case study is used by 70 % of the papers, followed by theoretical reasoning, experiment and action research.

Considering the type of the study presented in papers, Figure 6 shows that qualitative reasoning is the most popular one. 20 papers use qualitative reasoning, while of the remaining 4, 2 of them use quantitative study and 2 of them use a mixed approach, i.e. qualitative and quantitative.

Table 5 provides an insight into the relation between the type of the study and the research method used. As it can be seen in the Table 5, most papers use qualitative study type performed on a case study.

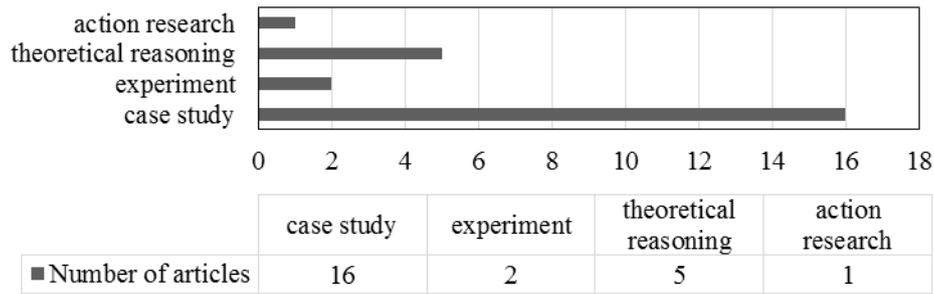


Figure 5. Research methods.

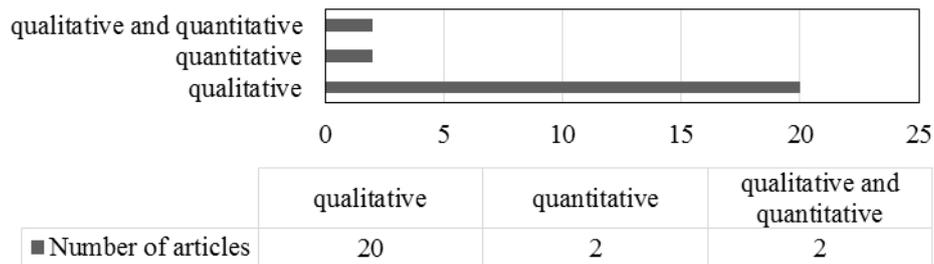


Figure 6. Study types.

Table 5. Type of study and research method by paper (continued on p.261).

| Paper | Year | Type | Research method | Validation |
|-------|------|----------------------------|-----------------------------------|--|
| [A10] | 2004 | qualitative | theoretical reasoning | AMACONT project used for developing component-based adaptive web presentations. Theoretical descriptions. |
| [A15] | 2004 | qualitative | case study | Simple demo applications |
| [A7] | 2005 | qualitative | case study | Authors created one e-learning course |
| [A11] | 2005 | qualitative | case study (explicitly mentioned) | Framework was developed and used on prototype. |
| [A16] | 2005 | quantitative & qualitative | action research | Authors developed a framework and used it in Rila Solution Company in Finance and Crediting domain. |
| [A17] | 2005 | qualitative | case study | Developed a prototype of a framework for Real Time Distributed Control Systems (RTDCS) |
| [A21] | 2005 | qualitative | theoretical reasoning | Theoretical explanations |
| [A25] | 2005 | qualitative | theoretical reasoning | Theoretical proposal of a framework |
| [A8] | 2006 | qualitative | case study | Prototype was created |
| [A9] | 2006 | qualitative | case study (explicitly mentioned) | Demonstration through various examples. |
| [A13] | 2006 | qualitative | case study | GOWARN concept from 2003 extended to new locations (AIS (atlas information system) for Campi Flegrei, a volcanic area near Naples, Italy). |

Table 5. Type of study and research method by paper (continuation from p.260).

| Paper | Year | Type | Research method | Validation |
|--------------|-------------|----------------------------|-------------------------------------|--|
| [A23] | 2006 | qualitative | case study | Math Test site was built as a prototype. |
| [A24] | 2007 | qualitative | case study | Method was used on prototype system National Agriculture Decision Support System (NADSS). |
| [A27] | 2007 | qualitative | case study | “..., several Web-Based product customization systems are developed for typical industrial enterprises.” [A27] |
| [A19] | 2008 | qualitative | case study | Real world applications, exp. “Portal e-Arte” |
| [A20] | 2008 | quantitative | case study (explicitly mentioned) | Large scale web application DSS that includes 2000 component and 500 pages. |
| [A5] | 2009 | quantitative | Experiment | Benchmark in using Jade Framework for construction of self-repairable cluster systems. |
| [A6] | 2011 | quantitative & qualitative | Experiment | Authors performed tests (login case). |
| [A14] | 2012 | qualitative | case study | Prototype was built “scrap exchange system” |
| [A12] | 2013 | qualitative | case studies (explicitly mentioned) | Various case studies in BMD Systemhaus GmbH company |
| [A18] | 2013 | qualitative | theoretical reasoning | Theoretical explanation of the model |
| [A26] | 2013 | qualitative | theoretical reasoning | Theoretical explanation |
| [A4] | 2014 | qualitative | case study | Prototype was built eCommerce, shopping chart application |

CITATION

The citation count of the selected papers (including the ones not accessible) is shown in the Table 6. Citing information was taken from Google Scholar in late April of 2014. The most cited paper is [A26] which has 56 citations. Several of the following papers have relatively good citation record, but on average there are 8 citations per paper. If we exclude the papers published in last four years (because they are fairly recent), the average number of citations per paper is 11. Therefore, we can conclude that research in component based web applications needs some further investigation due to relatively low publication and citation count. However, due to exclusion of SOA related papers which is becoming hugely popular research area, it is most likely that this effected the number of publications related to CBD and web development frameworks. Also, another limiting factor is the strong search criteria which states that the framework must be explicitly mentioned.

Table 6. Papers sorted by citation level.

| Paper | Title | Year | Cited by |
|--------------|---|-------------|-----------------|
| [A24] | A software architecture and framework for Web-based distributed Decision Support Systems | 2007 | 56 |
| [A10] | Design and Implementation of Component-based Adaptive Web Presentations | 2004 | 26 |
| [A15] | XVM: A Bridge between XML Data and Its Behavior | 2004 | 16 |
| [A11] | Towards end user development of Web applications for SMEs: A component based approach | 2005 | 16 |
| [A8] | Using the Amacont Architecture for Flexible Adaptation of 3D Web Applications | 2006 | 15 |
| [A19] | The WebComfort Framework: An Extensible Platform for the Development of Web Applications | 2008 | 11 |
| [A13] | Modular web-based atlas information systems | 2006 | 9 |
| [A4] | openMVC: A non-proprietary component-based framework for web applications | 2014 | 9 |
| [A22] | Modeling a web-based remote monitoring and fault diagnosis system with UML and component technology | 2006 | 8 |
| [A27] | Realization of a development platform for Web-based product customization systems | 2007 | 7 |
| [A20] | Shared Content Management in Replicated Web Systems: A Design Framework Using Problem Decomposition, Controlled Simulation, and Feedback Learning | 2008 | 6 |
| [A5] | A self-repair architecture for cluster systems | 2009 | 6 |
| [A9] | A component-based framework for knowledge discovery in bioinformatics. | 2006 | 3 |
| [A21] | Structural engineering: Processes and tools for developing component-based open hypermedia systems | 2005 | 2 |
| [A23] | A Framework for Developing Wireless Mobile Online Applications | 2006 | 2 |
| [A14] | A Web Application Framework for End-User-Initiative Development with a Visual Tool | 2012 | 2 |
| [A26] | The pataphysics of creativity: Developing a tool for creative search | 2013 | 2 |
| [A12] | Composing user-specific web applications from distributed plug-ins | 2013 | 1 |
| [A25] | A study on frameworks of component integration for web applications | 2005 | 0 |
| [A7] | Developing Customizable Web-based Educational Applications through a Component-based Framework | 2005 | 0 |
| [A16] | Towards development and use of in-house component framework: Results and expectations | 2005 | 0 |
| [A17] | Loose integration of COTS tools for the development of real time distributed control systems | 2005 | 0 |
| [A1] | A non proprietary framework for policy controlled management of the model in the MVC design paradigm (NOT READ) | 2005 | 0 |
| [A2] | A circuit board approach to building web applications (NOT READ) | 2006 | 0 |
| [A6] | Support for development and test of web application: A tree-oriented model | 2011 | 0 |
| [A3] | Component based webGIS development framework (NOT READ) | 2012 | 0 |
| [A18] | Nested web application components framework: A comparison to competing software component models | 2013 | 0 |

In Figure 7, which presents number of cited papers by year, it can be noticed that most of the citations are from between 2005 and 2006, more than 50 %. But surprisingly the most cited paper is from 2007, and the more recent one, from 2014 is cited 9 times. It will be interesting to see if the rising trend as seen from 2011 up to 2014 will continue.

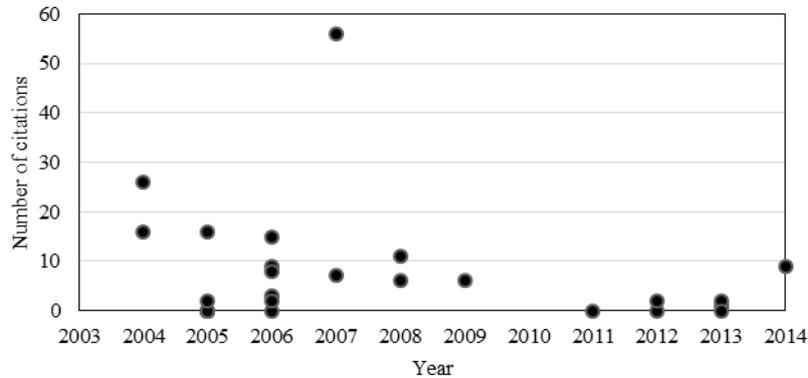


Figure 7. Citation level of papers by years.

USED CBD MODELS AND PROGRAMING LANGUAGES

In Table 7 and Figure 8 one can notice that 11 out of 24 papers haven't defined a component model. The most used component model is some variation of JavaBeans consequently making Java the most popular development language (usually J2EE).

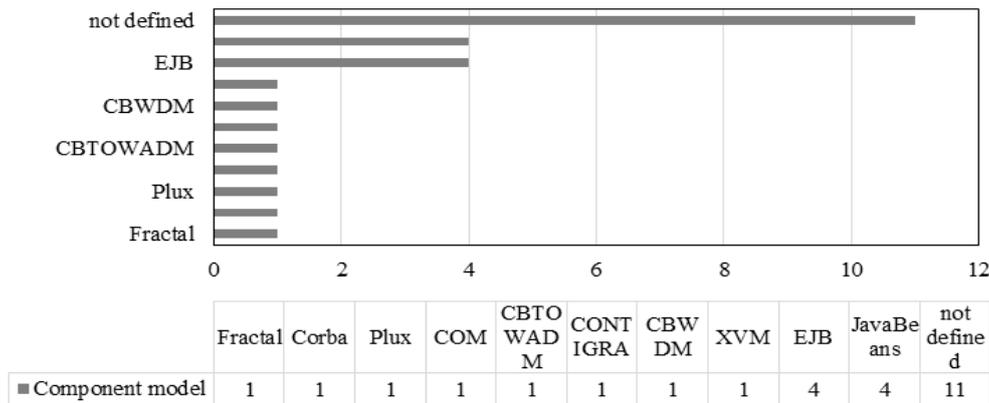


Figure 8. Component models.

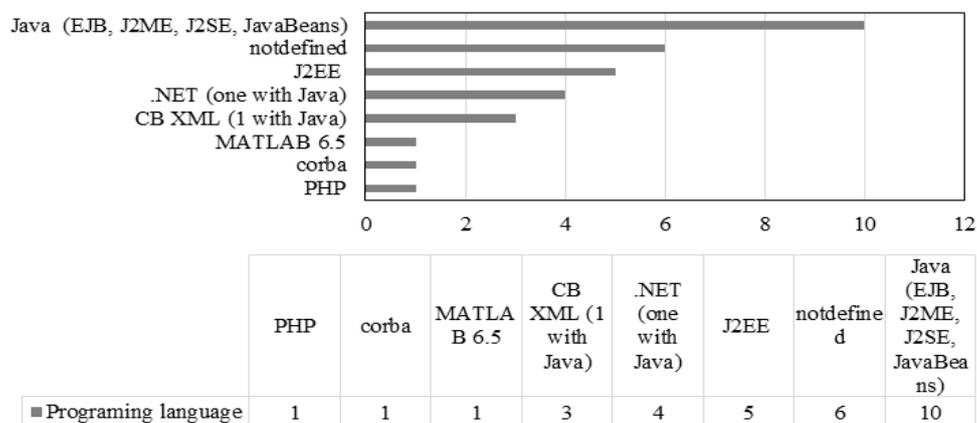


Figure 9. Programming languages.

Both JavaBeans and EJB are used in 4 papers. In 3 of them, JavaBeans and EJB are used simultaneously, 2 papers use COM and Corba component models which are well known, and the remaining ones use custom component models.

Considering programming languages (Figure 9), Java is most widely used, with 12 out of 21 papers using it. Among these, 10 of which using explicitly Java and in 2 paper Java is an option (papers [A21] and [A12]). Paper [A15] also uses Java, but only to build XML which is then used to develop web applications, therefore it is not counted since this XML can be generated in many programming languages.

Table 7. Overview component model & programming language.

| Paper | Component model | Programming language |
|-------|--|---|
| [A4] | not defined | .net, J2EE |
| [A5] | Fractal | Java |
| [A6] | CBTOWADM | not defined |
| [A7] | JavaBeans, EJB | J2EE |
| [A8] | Contigra | XML |
| [A9] | not defined | J2SE |
| [A10] | not defined | XML |
| [A11] | not defined | not defined |
| [A12] | Plux (plug and play like OSGi or SOFA 2.0) | .net (can be implemented in Java) |
| [A13] | EJB | Java, EJB |
| [A14] | not defined | Java Servlets with JSON |
| [A15] | XVM | Java for build XVM Framework, XML for building Web applications |
| [A16] | JavaBeans, EJB | J2EE, EJB |
| [A17] | JavaBeans, EJB | J2EE, EJB |
| [A18] | not defined | PHP + Smarty |
| [A19] | not defined | ASP .NET |
| [A20] | not defined | MATLAB 6.5 and a discrete-event simulator |
| [A21] | not defined | not defined, (any language is possible to use) |
| [A22] | COM | HTML, ASP, ActiveX, COM |
| [A23] | JavaBeans | J2ME, JavaBeans |
| [A24] | Corba, (possible to use DCOM, EJB) | Corba |
| [A25] | CWBDM | not defined, but proposed architecture is based on Java |
| [A26] | not defined | not defined, (any language is possible to use) |
| [A27] | not defined | not defined, (any language is possible to use) |

CBD BEST PRACTICES

Most papers do not explicitly report on any major problems while using the component approach, but rather they report suggestions for future researchers and practitioners concerned with CBD. All the suggestions are aggregated and presented in Table 8.

OVERVIEW OF FRAMEWORK USAGE

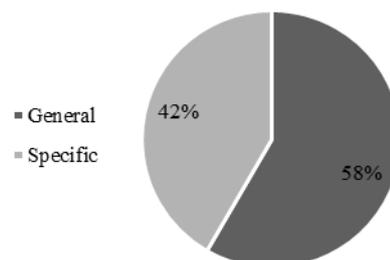
All the selected papers authors use some type of a web development framework, which can be divided in two groups; general and specific. General frameworks are used to develop any kind of web application, i.e. they can be used in many domains, while specific frameworks

Table 8. Suggestions for future component-based web framework development.

| Paper | Suggestion |
|-------|--|
| [A11] | Components should capture domain knowledge of web application development and hide complexities from End User |
| [A11] | Components should not capture application domain specific knowledge into Components. Rather those specific application needs should be abstracted and generic Components (Tools and Engines) should be created that can be used across many application domains.” |
| [A11] | Components should be easy to use by End Users, yet they need to be complete so that it aid full capture of all the necessary ‘Components parts’ of the application such as front end pages, back end processing logic and database information |
| [A16] | It is not an easy task to develop an in-house component framework or to integrate available preexisting COTS in enterprise applications. It actually needed far more efforts and investments than it was foreseen in the beginning (approximately 50% more work than expected).” |
| [A16] | It is not one time effort but continuous process, which needs considerable investment in time and resources. |
| [A16] | The percentage of reusability changes from application to application and often needs component modification and reconfiguration.” |
| [A16] | The major benefit of an in-house Component framework development surprisingly is not the project cost and time reduction based on business logic and business functions reusability (our but the company knowledge sharing and the creation of business function components |
| [A14] | Component composition: Each component is designed to achieve some special task; several components can be composed together in a dependent series to achieve a larger task. |
| [A14] | Problem in distributed systems is distributed component management. |
| [A18] | Problem is redesign of components to be more generic, simple and fast integration procedure with arbitrary Web applications. |

are specialized (or limited) to only a certain type of web application, i.e. a certain domain. As it can be seen in Figure 10, authors tend to use general frameworks, however the number of specific ones is fairly significant. Table 9 and Table 10 present a detailed overview of frameworks which are in the selected papers.

In Figure 11 the time dispersion of framework types is given. As it can be seen, in last four years general frameworks are preferred. Although there is one exception, one can notice that there seems to be the stabilization of the research domain. Initially, there was a lot of specific frameworks but due to growing complexity of web applications, researchers seem to use existing and already proven frameworks.

**Figure 10.** Framework types.

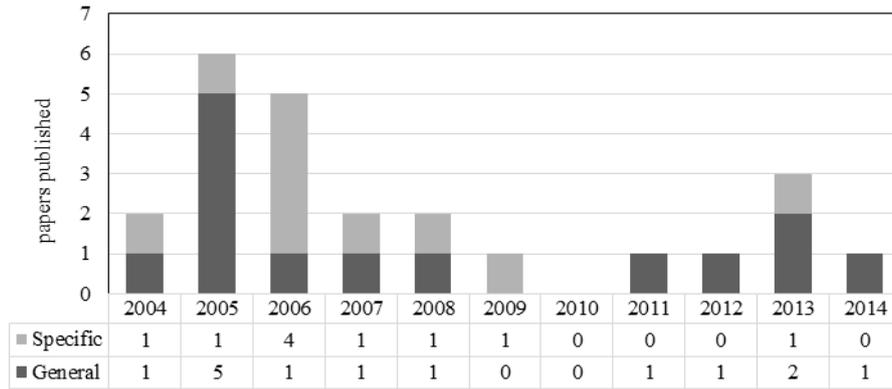


Figure 11. Type of frameworks per year.

Table 9. Overview of general frameworks (continued on p.267).

| Paper | Framework description |
|-------|--|
| [A4] | New model openMVC is a framework which enables building web applications that then can change Style Information, Layout and validation constraints updated without coding. eCommerce shopping cart application was built as a prototype. |
| [A6] | Framework for developing and testing web applications. Model (CBTOWADM) that is used simplifies the difficulty of web application testing. Authors focus on functional testing based on a UML model. Model can also be used for developing web applications. |
| [A11] | Framework which end-users use to develop web applications using components developed by web developers. This framework targets SME's (small and medium enterprise) web applications |
| [A12] | Plug-in framework Flux, for integrating components into web applications. |
| [A14] | Web app framework for end-user development, for end-users to quickly implement simple sites with backend logic, like using a database. Framework is meant for SME web applications. |
| [A15] | XVM is XML virtual machine used as framework for developing and deploying XML-based applications, it is not a programming language. XML application container is built on top of XVM. |
| [A16] | Component framework in which different components are plugged (containing specific business logic) in and then are used to build Web applications. Currently Finance and Crediting web applications was built. Some components are domain specific like portfolio management. |
| [A17] | Real Time Distributed Control Systems (RTDCS) is a Framework for loose integration of COTS tools. Idea is integration of domain specific COTS tools, in the sense of automatic interchange of formally expressed information through standard and free software middleware. A prototype was built, which integrates several COTS tools aimed to develop RTDCS. |
| [A18] | Framework that can easily be configured to work and integrate into an arbitrary application, and by configuring the framework, we configure all the components created using it and make those accessible to the host application. |
| [A19] | WebComfort (Framework) a dynamic component-based CMS platform which allows users to manage and operate complex web applications in a dynamic and integrated fashion. |
| [A21] | Framework for developing component based open hypermedia systems (CB-OHS). |
| [A23] | Framework that makes the modeling, implementation, and maintenance of wireless mobile online applications intuitive and easy, especially for students and beginners. Framework decomposes a complex online application into modules. Each module is a plug-and-play unit. The components in the libraries can be directly called and used. |

Table 9. Usage of CBD and connection to architecture (continuation from p.266).

| Paper | Usage of Components | Connection to architecture |
|--------------|--|-----------------------------------|
| [A25] | Framework for developing web applications using COTS components. | |
| [A27] | Framework for developing any kind of web applications used in typical industrial enterprises. Framework gives a repository of components that can be used and customized to build new web applications, especially suitable for small and mid-sized enterprises with low IT expertise. | |

Table 10. Overview specific frameworks.

| Paper | Framework description | Domain, kind of applications |
|--------------|--|---|
| [A5] | Jade Framework for construction of self-repairable cluster systems. System analyses itself, and when failure is detected it start analyzing and repairs (reconfigures) from these failures based on system map. | distributed cluster systems of any kind |
| [A7] | WebMODE is component-based framework for developing e-learning web applications. WebMODE is semi-complete application that can produce specialized applications (eLearning). | eLearning applications |
| [A8] | Framework that uses adaptive hypermedia architecture AMACONT together with the component-oriented 3D document model CONTIGRA to achieve various types of 3D adaptation within Web pages. | 3D Graphics Web applications (e-Commerce, e-learning, 3D collaboration, ...) |
| [A9] | Enhance reusability and productivity for shot timeline projects in the field of bioinformatics to integrate all knowledge discovery. Paper gives architecture description for IKDD (interactive knowledge discovery and data mining) and demonstration through examples | biomedicine (bioinformatics) |
| [A10] | Developing component-based adaptive web presentation. Developing web presentations out of components. | adaptive web presentations |
| [A13] | Framework for building web based modular AIS systems. | Atlas Information Systems |
| [A20] | Systematic framework for designing and evaluating large-scale, component-based replication architectures for Web systems. Framework employs a combination of problem decomposition, configuration evaluation through controlled system simulations, and a neural-network-based feedback learning mechanism in the exploration of the design space. | decision support tool for a system designer to systematically explore design options and select an appropriate design configuration that best meets the design objectives |
| [A22] | Reusable WRMFDS model, aims at making such advanced information technologies be used widely in the condition monitoring and fault diagnosis domain, it can give developers a paradigm to accomplish the similar systems. | monitoring web applications |
| [A24] | Method to help design and implement a Web-based Decision Support Systems (DSS) in a distributed environment. Method was used on prototype Framework. | web based DSS (decision support systems) |
| [A26] | Method to build creative web search engines using the pataphysics. | Creative web search engines |

Table 11. Usage of CBD and connection to architecture (continued on pp.269-271).

| Paper | Usage of Components | Connection to architecture |
|--------------|--|---|
| [A10] | Components are documents, content-units or media types, which are used for construction of web presentations in component-based way. | Pipeline-based architecture is used which uses the components to generate final presentations. Everything is based on XML. |
| [A15] | “Components are responsible for realizing the application logic related to the associated element and providing services to other components.” [A15] | XVM architecture is component-based architecture and also enables dynamic composition of components. XVM manager is responsible for handling all components. “In the XVM architecture, the key idea is a mapping between XML elements and software components, which associates XML elements with software components.” [A15] |
| [A7] | Component are business rules, but because WebMODE is based on J2EE architecture, many other parts are also components. | WebMODE is based on J2EE architecture and uses the MVC design pattern. “J2EE web components are used to implement the presentation logic that connects the client interface to the business rules.” [A7] |
| [A11] | Two types of Components: “(a) Tools that allow End Users to create and assemble applications and (b) Engines that could be used to run these applications.” [A11] | Architecture not particularly described. Framework is built so that end-users can use existing components to build new applications, or developers can create new component include into Framework and this can be further used again by end-users. |
| [A16] | Components contain business logic or presentation logic, with connectors to HTTP, JDBC, JNDI, CORBA, RMI | Architecture is multi-tier (client, web (presentation), business, and database). Components are used at web and business tier. |
| [A17] | Components are generated by different tools. These components are then used to build new applications. Enterprise Java Beans are a group of classes responsible for achieving the tasks implied in the business logic (the implementation of the services offered over RTDCS data). | The Model Collaboration Engine (MCE) architecture is based on View Model Approach. “Each of the Domain-Specific Models shows only the information about the system relevant to a specialist (or tool). Four models or views (more can be added) are identified as Domain-Specific: Control System (architecture independent system functionality), Distribution System (network topology and services), Real Time System (software architecture and temporal issues) and Software Engineering (code and documentation generation).” [A17] |
| [A21] | “Component/Structure server: Reifies the domain specific abstractions, providing the domain specific services to clients. They are semi-autonomous components, since they rely on the infrastructure services for common functionality. They establish a well-defined interface for communication with client applications.” [A21] | Layered architecture is used in CB-OHS. These tiers are: client, structure server (components) and infrastructure. |

Table 11. Usage of CBD and connection to architecture (continuation from p.268, continued on pp.270-271).

| Paper | Usage of Components | Connection to architecture |
|--------------|--|--|
| [A8] | Component are used for document modeling. | AMACONT architecture with the component-oriented 3D document model (CONTIRGA). "AMACONT architecture processes component-oriented XML documents within the adaptation pipeline." [A8] |
| [A9] | Components are part of the Core architecture of IKDD Framework. Components are integrated in the third layer. "All components have to be subclasses of the abstract class AComponent. ... The AComponent class provides an intuitive and complete set of methods to program a new component." [A9] | Layered architecture is used (Database, Core, third layer, application layer). "The core package from iKDD models the component abstraction, implements a graph-based processing module, and covers basic components e.g. XML import / export." [A9] |
| [A13] | Components have specialized functionalities to client modules that require server-based functionality (e.g. data analysis or computation of visualizations that require large data set). | Client-server architecture is used. Components are used on server side. |
| [A22] | "Using component-based programming, we developed a highly maintainable system, which contains three components packages: Monitoring Controls Package based on ActiveX, Analysis Controls Package based on ActiveX, and Diagnosis Algorithms Package based on COM." [A22] | "A four-tier model based on the Microsoft's tier concept is adopted in the WRMFDS, which consists of the Presentation Services Tier, the Application Services Tier, the Data Access Services Tier and the Database Services Tier." [A22] |
| [A23] | Layered structure of components is used. The top layer consist of components which are used to build final applications (exp. welcome component, login components ...). | Three-tired-architecture is used (MVC pattern). The tires are: server, client and databases. Components are used on server side. "A request-response pair contains three parts (Model, View, controller) and forms a unit. Each unit is implemented by reusing component libraries in the layered component structure and each unit can be plug-and-play into the system." [A23] |
| [A24] | "There are three major roles in the 3CoFramework: component implements or wraps the domain-specific computational logic or data access; a connector implements the component interaction; a coordinator implements the distributed components and connectors management." [A24] | Layered software architecture is used (Data, Information, Knowledge, Presentation) and components are used in each of these layers |

Table 11. Usage of CBD and connection to architecture (continuation from pp.268-269, continued on p.271).

| Paper | Usage of Components | Connection to architecture |
|-------|---|--|
| [A19] | Components are different platform features. | In the paper they say that Component-based architecture is used. Architecture consist of: (1) Modules; (2) toolkits; (3) extenders; (4) data repository access; (5) module actions; and (6) the WebComfort API. As small connections between components as possible. Paramount to some of these aspects was the usage of the Provider pattern, which is a mix of the Abstract Factory, Strategy and Singleton patterns. |
| [A20] | Components are content created form three layers. "A Web application can usually be described in three layers. Presentation layer, business logic layer, and database layer. Each layer can be partitioned and distributed among the CDN's replica servers; In such replication approaches, <i>content elements drawn from the three layers are structured into components that are replicated</i> . The components are then dynamically assembled and delivered from the replica servers when they are requested." [A20] | Hierarchical component-based content architecture is used. Where components are at the lowest layer. Hierarchy, top down: application, site view- web page, components. |
| [A5] | Component is every tier in JEE multi-tiered architecture which is wrapped with JADE Framework. | "In a JEE multi-tiered architecture, the Web server is classically divided in several tiers: the HTTP daemon (Apache), the servlet engine (Tomcat), the EJB business server (JOnAS), and the database tier (MySQL for e.g.). Each tier is independently wrapped in a component." [A5]. Entire JADE framework is based on FRACTAL component-model. "Fractal is used in Jade in three main ways: (i) to construct the Jade software framework itself; (ii) to construct managed systems or to wrap legacy managed elements; (iii) to construct the System Map – a causally connected representation of the managed system model." [A5] |
| [A6] | Web application is divided into modules, module into sub module and sub module into components which realizes some function. "A component of CBTOWADM can be a dynamic link library, a web page, the logic function of a web page, a class, a web service, a database or a table of a database, an image file, and so on." [A6] | Component-based and tree-oriented web application development model (CBTOWADM) describes the software architecture. |

Table 11. Usage of CBD and connection to architecture (continuation from pp.268-270).

| Paper | Usage of Components | Connection to architecture |
|-------|--|--|
| [A14] | <p>Component implement backend functionalities, which end-users can use when building web applications (exp. search component for searching some data table).</p> <p>Two types of components: Components that implement functionalities that are not domain dependent and components that are domain-dependent.</p> | Three-tiered-architecture (client, application server, DB server) with MVC pattern is used. Components are used in application server. |
| [A12] | <p>Component can be anything. Every user can add his own components. Components can be server-side that are installed and executed on server. Client-side installed and executed on client and use local resources. And sandbox components installed on server and downloaded to client on demand and executed on sandbox on the client.</p> | Component based plug-in architecture. Different components are combined by end users and web applications created. |
| [A18] | <p>Framework itself is a component that can be integrated into other web applications, but also consist of components which consist of components "nested components".</p> | MVC architecture, components are used on all MVC layers. |
| [A4] | <p>Components are used in all parts of the architecture for implementing all kind of functionalities, like styling component, validation constraint component, etc.</p> | Five layers architecture (client, presentation logic, business logic, data abstraction, database), each layer has components for some specific functionalities. |
| [A25] | <p>There are 4 kinds of components (domain, common business, base business) each with their own sub components which are used in new web applications build from end users.</p> | Each component type is a specific module in the overall architecture. "We have identified web components and layered on ABCD architecture"[A25] |
| [A26] | <p>Components are used to implement algorithm for creative web searching. "More advanced students could also develop their own components to test out theories and improve their understanding of the base concepts of not just search engines but the various fields that play a role in information retrieval systems." [A26]</p> | "... component-based software architecture has been proposed which will allow for a range of different style systems to be developed with little overhead, thereby improving the chance of creative outcomes occurring in a different way." [A26] |
| [A27] | <p>Components are used for building new web applications. They are used by end-user when they build their applications and users can customize the components with some parameters depending on their needs.</p> | There are component-based application modules (parameter based, configuration based document based, description based), this modules is responsible for using of components based different types of customization. For example XML descriptors are used in the parameter based customization. |

Table 11 shows for which purpose authors used component based development and how did it affect the software architecture of their web applications. There are three ways of component approach usage which one can distinguish:

- Components are used for creating web development frameworks – in this approach authors create component based frameworks which are used to create web applications, which can, but don't need be component based.
- Components used as application building blocks – in this approach components are used to create component oriented web applications without the underlying framework.
- Mixed approach – both framework and web application developed with this framework are component oriented.

In all the above cases the architectural decision is made solely by the end user, and all papers report only on developing prototypes (whether it is a framework or a web application). While most of the authors use component approach on the server side to implement various services, on the client side, 11 papers report using n-tier architecture, thus making it the most common.

SUGGESTIONS FOR FUTURE RESEARCH

If one is interested component approach and web development frameworks the most relevant scientific databases are Scopus, Springer and IEEE which will cover most of the related publications. Currently, the most relevant publications (2/3 of them being conference proceedings) were published between 2005 and 2006 which is most likely due the popularization of Web 2.0.

According to the selected papers here are some interesting research directions for the future:

- Graphical tools for creating application models which are then exported to XML schemas and automatically translated into component templates for creating web applications [A11].
- Enhancement of security, creating security models, and develop a complete XML virtual machine (XVM, XMLVM) development process model (analysis, deployment evaluation, performance evaluation, etc.) [A15], [A12].
- Refine components to reduce end-user effort to develop web applications, minimize faults, handle exceptions [A11].
- Research into component approach and mixed-media web applications [A8].
- Implementation of unified conceptual models and component libraries [A22].
- Model driven development approach for component web applications [A19].
- Research into verification models and tools for building component based web applications [A6].

It is apparent that component based approach is becoming a serious architectural direction and there is a very recent working groups focused solely on component based development for web, including the one from the W3C [9, 10].

CONCLUSION

In this paper we presented a literature review on component based development relation to web application frameworks. The original pool of related publications had 1132 papers which were, by the strict set of rules filtered out to 27 papers. Since three of them were inaccessible, 24 of them made it through to the full analysis which resulted in answers to the research questions Q_{1-4} .

Q₁: *In which way is CBD used for web application development?* - There are three main approaches: a) component approach is used for creating component based frameworks which are then used for creating web application (not necessarily component oriented), b)

component approach is used for building components which are the building blocks of web applications, and c) a mix of two previous approaches. In approach a) and c) the end user decides whether to use component approach for web application development while in b) component approach is imposed to the end users.

Q₂: *What is the relation between CBD and web application development?* – Component approach is used mostly for server side applications. Using it on the client side is less common, but there are cases and end-users aren't constrained to use it. Most widely used architecture is n-tired with components used inside different layers. For any future researchers and practitioners it is strongly suggested to plan component approach right from the start of the application design process. Although it requires more time, true benefits (separation of concerns, better maintainability, scalability, replaceability, single point of edit, etc.) are apparent later.

Q₃: *Which component models are used for web application development?* – Based on the reviewed papers it is obvious that EJB and Java beans are most preferable component models, hence Java being also the most popular programming language for this purpose. Although, it should be noted that there are a lot of custom models also. Since Java/J2EE is a leader in this field future researchers and practitioners have a choice to make, weather to expand the existing Java based component models or create new ones which requires more time, however offers new possibilities independent of a single technology.

Q₄: *In which web application development domains is CBD used?* – It is hard to recognize distinct domains however there are two types of web application development frameworks presented in the selected publications: a) general; used for any kind of web applications and b) specific; for developing special purpose web applications (e.g. eLearning, 3D graphics, monitoring, etc.). Majority of selected papers (14) describe the general framework.

Finally, the answer to the overall research question (i.e. how much of the current web application development frameworks explicitly refer to application of component-based approach) is hardly intuitive. It is apparent that most of the papers which are selected explicitly referee to component based approach, however this is the result of the selection process. While making decision, one should keep in mind the fact that the answers arise from a small number of processed papers (after filtering process). Nevertheless the answers are interesting and give an indication what is happening in the presented field. Review with more papers included should be performed to have a broader overview of the field.

There is a lot of publications dismissed which are related to SOA, and it would be very useful to perform an additional literature review with the same focus but focused on SOA. Considering the number of papers published, it is apparent that in the past there was a minor setback of this research area however, there is a growing trend. Although component based approach is more popular in other software engineering domains, with appearance of SOA, and Web 2.0 the number of component model is growing and we envision it will still grow, especially with W3C involvement. Therefore we reckon that any future web framework researchers and practitioners should be acquainted with component based development techniques, as it will become more popular in the near future.

APPENDIX A. EXTRACT OF SEARCH QUERIES

Here are the search queries for each database:

- SCOPUS (<http://www.scopus.com>)
 - TITLE-ABS-KEY((web AND development) OR (web AND architecture)) AND TITLE-ABS-KEY("component based" OR "component-based" OR "CBD")
 - **691 findings without restrictions (Language, Year), 677 without "CBD" keyword**

- ACM Digital Library (<http://portal.acm.org>)
 - (((Title:web and Title:development) OR (Title:web and Title:architecture)) and (Title:"component based" OR Title:"component-based" OR Title: "CBD")) OR (((Abstract:web and Abstract:development) OR (Abstract:web and Abstract:architecture)) and (Abstract:"component based" OR Abstract:"component-based" OR Abstract:"CBD"))
 - **296 findings without restrictions (Language, Year)**, 291 without "CBD" keyword
- IEEE Xplore (<http://ieeexplore.ieee.org>)
 - ((web AND development) OR (web AND architecture)) AND ("component based" OR "component-based" OR "CBD")
 - **326 findings without restrictions (Language, Year)**, 325 without "CBD" keyword
- ScienceDirect (<http://www.sciencedirect.com>)
 - TITLE-ABSTR2-KEY((web AND development) OR (web AND architecture)) and TITLE-ABSTR-KEY("component based" OR "component-based" OR "CBD")
 - **34 findings without restrictions (Language, Year)**, 33 without "CBD" keyword
- ISI Web of Science (<http://www.isiknowledge.com>)
 - TS=(((web AND development) OR (web AND architecture)) AND ("component based" OR "component-based" OR "CBD")) OR TI=(((web AND development) OR (web AND architecture)) AND ("component based" OR "component-based" OR "CBD"))
 - **146 findings without restrictions (Language, Year)**, 141 without "CBD" keyword
- TOTAL (All databases) **1492 findings without restrictions (Language, Year)**, 1467 without "CBD" keyword

APPENDIX B. PAPERS OF THE STUDY

- [A1] A. Jackson and J. G. Keating, "A non proprietary framework for policy controlled management of the model in the MVC design paradigm," in ICEIS 2005 - Proceedings of the 7th International Conference on Enterprise Information Systems, 2005, pp. 451–454.
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PREDVIĐANJE GUBITKA KLIJENATA U BANKARSTVU KORISTEĆI NEURONSKE MREŽE

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SAŽETAK

Glavni cilj ovog rada je prikazati studiju slučaja uporabe jedne od metoda rudarenja podataka, neuronskih mreža, u otkrivanju znanja iz baza podataka u bankarstvu. Rudarenje podataka je automatizirani proces analiziranja, organiziranja ili grupiranja velike količine podataka iz različitih izvora i sumiranje u korisne informacije koristeći posebne algoritame. Rudarenje podataka može pomoći u rješavanju bankarskih problema pronalazeći neke pravilnosti i veze između poslovnih informacija koje nisu vidljive na prvi pogled jer su skrivene u velikoj količini podataka. U ovom radu smo koristili jednu od metoda rudarenja podataka, neuronske mreže, unutar programskog paketa Alyuda NeuroInteligence kako bi predvidjeli gubitak klijenata u banci. Glavni problem kod gubitka klijenata je pronalači klijenata koji bi mogli otići kod konkurencije i utvrditi koji su klijenti vrijedni zadržavanja. Neuronska mreža je statistički model učenja inspiriran ljudskim mozgom, a koristi se za procjenu funkcija koje mogu ovisiti o velikom broju ulaza koji su općenito nepoznati. Iako je metoda vrlo složena, postoje alati koji omogućavaju uporabu neuronskih mreža bez velikog predznanja o tome kako one rade. Dobiveni rezultati pokazuju da klijenti koji koriste više usluga banke (proizvoda) su lojalni, pa se banka treba usmjeriti na one klijente koji koriste manje od tri proizvoda, i ponuditi im proizvode u skladu s njihovim potrebama. Slični rezultati su dobiveni različitim mrežnim topologijama.

KLJUČNE RIJEČI

rudarenje podataka, neuronske mreže, bankarstvo, gubitak klijenata

MODELIRANJE DOSTUPNOSTI INFORMACIJSKOG SUSTAVA BAYESOVOM MREŽOM POVJERENJA

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SAŽETAK

Za moderne informacijske sustave očekuje se kako uvijek pružaju usluge krajnjim korisnicima, neovisno o vremenu i lokaciji. Ovo je posebno značajno za organizacije i industriju u kojima informacijski sustavi podržavaju djelovanja u stvarnom vremenu i kritične primjene koje moraju biti dostupne po pristupu $24 \times 7 \times 365$. Primjeri takvih cjelna uključuju procesnu industriju, telekomunikacije, zdravstvenu skrb, bankarstvo, elektroničko trgovanje i niz tehnologija u oblaku. Ovaj rad koristi modificirani model Bayesove mreže povjerenja za predviđanja dostupnosti informacijskih sustava. Model su postavili autori U. Franke i P. Johnson (u radu *Availability of enterprise IT systems – an expert-based Bayesian model*, objavljenom u časopisu *Software Quality Journal* **20**(2), 369-394, 2012.). Na temelju sveobuhvatnog pregleda dostupnosti informacijskih sustava s više stajališta predlažemo modificirani skup odrednica. Model je parametriziran pomoću procesa elicitanje vjerojatnosti uz sudjelovanje stručnjaka financijskog sektora Bosne i Hercegovine. Model je validiran Monte-Carlo simulacijom.

KLJUČNE RIJEČI

informacijski sustavi, kontinuitet poslovanja, dostupnost, Bayesove mreže povjerenja, Monte-Carlo simulacije

NEUROMARKETING U ISTRAŽIVANJU TRŽIŠTA

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SAŽETAK

Neuromarketing je relativno nova disciplina koja kombinira saznanja iz bihevioralne psihologije, ekonomije i neuroznanosti o potrošačima. Uz pomoć različitih tehnika, poput funkcionalne magnetske rezonance, elektroencefalografije, pozitronske emisijske tomografije, eye tracking-a i drugih, mjeri ispitanikovu reakciju na različite podražaje. Omogućuje istraživačima da dobiju uvid u podsvjesne mehanizme izbora i preferenci koje ne bi bili u mogućnosti otkriti sa tradicionalnim metodama (fokus grupe, dubinski intervju i ankete). U istraživanju tržišta se najčešće koristi uređaj za praćenje pokreta zjenice (eng. *eye tracker*). Uobičajena studija iz istraživanja tržišta, koja se odnosi na ispitivanje TV reklame, provedena je pomoću stacionarnog uređaja za praćenje pokreta i alata *Gazepoint*. U studiji je učestvovao 21 ispitanik. Utkriveno je kako je jedna scena u reklami privukla puno više pažnje od ostalih scena. Obzirom da se uz primjenu neuromarketinga vežu i neka etička pitanja, napravila sam i osvrt na radove koji su se bavili tim pitanjima, kao i pregled neuromarketinga i njegovih tehnika.

KLJUČNE RIJEČI

neuromarketing, *eye tracking*, istraživanje tržišta, etika

INOVATIVNOST I SPOSOBNOST INFORMACIJSKE TEHNOLOGIJE KAO PREDUVJETI USPJEHA TVRTKE

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SAŽETAK

Glavni cilj ovog rada je uočavanje preduvjeta za uspjeh tvrtke u specifičnim uvjetima nove ekonomije. Više istraživača nastojalo je odgovoriti na pitanje zašto neke tvrtke stalno nadmašuju druge. Jedno od najzastupljenijih stajališta vezano uz ovo pitanje je stajalište utemeljeno na resursima, odnosno teorija utemeljena na resursima. Prema toj teoriji, izvori kompetitivne prednosti započinju stavom kako su razlike u izvedbi suštinska posljedica vrijednih, rijetkih, jedinstvenih i nezamjenjivih resursa i sposobnosti. Informacijska tehnologija kao resurs tvrtke poprima rastuću važnost za istraživanja i menadžere. Istraživanja vrijednosti informacijske tehnologije kao dijela sposobnosti informacijske tehnologije neke organizacije ili tvrtke, proširila su se tijekom zadnjeg desetljeća. Sposobnost informacijske tehnologije definirana je kao postojanje infrastrukture, znanja i operacija informacijskih tehnologija unutar tvrtke. Svrha ovog rada je analiza kako na poslovanje tvrtke utječe međudjelovanje sposobnosti informatičke tehnologije i inovativnosti tvrtke. Istraživanje pokazuje kako su i sposobnost informatičkog sustava i sposobnost za inovacije značajni u postizanju boljeg poslovanja tvrtke. Rezultati pokazuju kako se menadžeri trebaju koncentrirati na razvoj funkcija informatičke tehnologije unutar tvrtke uzimajući u obzir značaj ulaganja u informatičke tehnologije, značaj znanja o informatičkim tehnologijama i inovativnost.

KLJUČNE RIJEČI

sposobnost informacijske tehnologije, inovativnost, stajalište temeljeno na resursima, poslovno djelovanje

INSTITUCIJE, OBRAZOVANJE I INOVACIJE I NJIHOV UTJECAJ NA EKONOMSKI RAST

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SAŽETAK

Cilj rada je dati detaljniji pogled na institucije, njihov razvoj, obrazovanje i inovacije te njihov utjecaj na ekonomski rast. Postulati neo-klasičnih teorija ekonomskog rasta uzimaju akumulaciju ljudskog kapitala i tehnološki razvoj kao faktore koji promoviraju ekonomski rast. Dakle, ulaganje u obrazovanje, istraživanje i razvoj kao i u inovacije bitno je za mogućnost ekonomskog rasta države. Međutim, glavna ideja ovog rada je izlaganje navedene teme sa stajališta institucija. Na temelju literature i statističke analize rad istražuje je li stupanj institucionaliziranja državnog obrazovnog sustava dovoljan za omogućavanje ekonomskog rasta države. Uspoređujemo četiri različite države, Makedoniju i Srbiju kao države van Europske Unije te Bugarsku i Sloveniju kao članice Europske Unije. Provodimo dvije analize – prva je usporedba određenih statističkih podataka a druga je usporedba indeksa ljudskog razvoja u četiri navedene zemlje. Rezultati istraživanja ukazuju na činjenicu kako je za institucionalizirano društvo većeg stupnja razvoja institucija, u ovom slučaju obrazovnog sustava, veća vjerojatnost započinjanja ekonomskog rasta. Rezultati također ukazuju na činjenicu kako je za društva u kojima je viši stupanj razvoja institucija, u ovom slučaju u Sloveniji i Bugarskoj, vjerojatnije stvaranje visoko kvalificirane i osposobljene radne snage koja će nadalje doprinostiti ekonomskom rastu.

KLJUČNE RIJEČI

institucije, obrazovanje, istraživanje i razvoj, inovacije, ekonomski rast

UTJECAJ PREDANOSTI POSLOVNE ETIKE NA NEFINANCIJSKE POKAZATELJE USPJEŠNOSTI POSLOVANJA

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SAŽETAK

U članku se istražuje odnos između predanosti poslovne etike i nefinancijskih pokazatelja uspješnosti poslovanja. Podaci o predanosti poslovne etike i nefinancijskim pokazateljima poslovanja prikupljeni su anketnim istraživanjem na bazi 100 sudionika. Istraživanje je provedeno u velikim i srednjim hrvatskim tvrtkama 2015. godine. Upitnik za procjenu predanosti poslovne etike mjerio je devet različitih dimenzija, dok se nefinancijska uspješnost poslovanja mjerila kroz tri dimenzije: zadovoljstvo klijenata, upravljanje ljudskim resursima, inovativnost te učinkovitost poslovnih procesa. U analizi podataka koristila se višestruka regresija. Empirijski rezultati triju višestrukih linearnih regresijskih modela pokazuju da određena dimenzija predanosti poslovne etike ima pozitivan utjecaj na nefinancijske pokazatelje uspješnosti poduzeća. Motivacija i politika nagrađivanja za etičko ponašanje te reagiranje na neetičko ponašanje, kao dimenzija predanosti poslovnoj etici, ima značajan utjecaj na sve tri nefinancijske dimenzije uspješnosti. Također je utvrđeno da odabir dobavljača na temelju standarda etike i usklađenosti ima pozitivan i snažan utjecaj na zadovoljstvo korisnika dok korištenje etičkih kriterija u ocjenjivanju radne uspješnosti i učinkovitosti zaposlenika ima pozitivan i značajan utjecaj na inovativnost i učinkovitost poslovnih procesa. Ovo istraživanje upućuje na zaključak da neke dimenzije predanosti poslovne etike mogu biti važni prediktori nefinancijske uspješnosti poslovanja poduzeća. Dakle, rezultati istraživanja mogu se smatrati valjanom motivacijom za daljnje povećanje predanosti etici u poslovnom okruženju.

KLJUČNE RIJEČI

poslovna etika, uspješnost poslovanja, predanost poslovnoj etici, višestruka regresija, nefinancijske dimenzije poslovanja

MASIVNI OTVORENI MREŽNI KOLEGIJI U OBRAZOVANJU IZ ROBOTIKE

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Sveučilište u Szegedu – Fakultet inženjerstva, Laboratorij robotike
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SAŽETAK

U novije vrijeme zahtjevi na podučavanje stalno rastu. Masivni, otvoreni mrežni kolegiji predstavljaju edukacijsku revoluciju stoljeća. To su mrežni kolegiji dostupni neograničenom broju sudionika, otvorenog pristupa na mreži. Vodeći sudionici u takvim kolegijima su *Coursera*, *Udacity* (od 2012. godine, na Sveučilištu Stanford) i *edX* (na Sveučilištima Harvard i MIT od 2012. godine). U radu se razmatraju dva masivna, otvorena mrežna kolegija: „Uvod u robotiku“ i „Robotska vizija“, oba sa Tehnološkog sveučilišta Queenslanda.

KLJUČNE RIJEČI

MOOC, masivni otvoreni mrežni kolegiji, robotika, *Coursera*, *Udacity*, *edX*

NOVA NORMA ISO 9001:2015 I NJENI UČINCI NA ORGANIZACIJE

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SAŽETAK

Norma ISO 9001 je općeprihvaćena međunarodna norma koja definira zahtjeve za sustav upravljanja kvalitetom (QMS). Organizacije implementiraju zahtjeve norme ISO 9001 s ciljem dokazivanja da njihovi proizvodi i usluge u potpunosti zadovoljavaju zahtjeve kupaca i regulative. ISO 9001 je najpopularnija norma iz serije ISO 9001 i jedina norma iz iste serije koja se može certificirati.

Nova verzija ISO 9001 objavljena je u rujnu 2015. godine te su napravljene mnogo značajnije promjene u odnosu na izdanje ISO 9001 iz 2008. godine. Na prvi pogled je jasno vidljiva promjena u strukturi norme ISO 9001:2015 gdje je broj poglavlja proširen s osam na deset poglavlja. Rad prezentira i pojašnjava najbitnije promjene u normi kao što su kontekst organizacije, promišljanje na bazi rizika, znanje kao resurs i vođenje.

KLJUČNE RIJEČI

sustav upravljanja kvalitetom, kontekst organizacije, promišljanje na bazi rizika, vođenje, ISO 9001:2015

VOĐENJE SUSTAVA MIGRACIJA: SLUČAJ IZRAELA

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SAŽETAK

Cilj ovog istraživanja je naznačiti kontrolne procese sustava migracija. U radu se sustav teritorijalnih migracija razmatra kao kompleks migracijskih tokova vezanih uz specifično geografsko područje, uklopljen u šire društveno-ekonomske sustave i prirodni okoliš, intenzivno međudjelujući s tokovima informacije i mase na tom području.

Istraživanje je provedeno kvalitativnim metodama za istraživanje značajnih informacija iz posebne ili fiktivne literature, sredstava javnog priopćavanja i mrežnih izvora. Teorijski okvir rada temelji se na analizi društvenih pojava pristupom sustava.

Analiza pokazuje kako je samoorganizirano vođenje odgovorno za veći dio kontrolnih procesa sustava migracija. Vođenje u sustavu migracija je kolaž različitih društvenih aparata koji prisilno surađuju na usmjeravanju aktivnosti migranata. Kolaž kao forma vođenja sustava migracija nije jedina mogućnost, ali je vrlo prikladna za nestabilni karakter migracijskog sustava, a time i najvjerojatnija. Vođenje je najistaknutiji formativni element Izraelskog sustava migracija jer kontrolira migracijske tokove te etničku i ekonomsku strukturu zemlje, zbog čega treba biti posebno istražen. Teorijska novina ovog istraživanja je u razdvajanju uloge i strukture vođenja u sustavu teritorijalne migracije i njegovog utjecaja na širi društveni sustav.

KLJUČNE RIJEČI

vođenje, sustav migracija, kompleksnost

NEDOHVATLJIVOST POUČAVANJA USMJERENOG NA POLAZNIKE

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SAŽETAK

Ovo istraživanje bavi se stilovima poučavanja sveučilišnih profesora. Stil poučavanja predstavlja okvir za odluke u poučavanju koje se donose tijekom cjelokupnog procesa poučavanja – planiranje, dostavljanje i evaluacija. Suvremene sveučilišne profesore potiče se na usvajanje stila poučavanja usmjerenog na polaznika budući da se smatra kako će to dovesti do brojnih novih mogućnosti. U zimskom semestru nastavne godine 2015/2016 su anketirana 52 ispitanika, polaznika fakultetâ Međunarodnog sveučilišta u Sarajevu, pomoću skale *PALS* koju je postavio Gary J. Conti. Dobiveni rezultati u skladu su sa smjericama autora skale. Rezultati su pokazali kako većina ispitanika snažno podržava poučavanje usmjereno na nastavnika umjesto poučavanja usmjerenog na polaznika. Rezultati su analizirani prema spolu i za tri različita fakulteta: Fakultet umjetnosti i društvenih nauka, Fakultet menadžmenta i javne uprave te Fakultet prirodnih i tehničkih nauka. U pet dobivenih grupa nijedan od indikatora stila poučavanja nije bio usklađen s kriterijima za poučavanje usmjereno na polaznika. Nije bilo statistički značajnih razlika između preferencija prema stilu poučavanja ni obzirom na spol niti obzirom na fakultet ispitanika. Rezultati istraživanja upućuju na to da stil poučavanja usmjeren na polaznika nije dostatno zastupljen. Nadalje, rezultati pokazuju kako uvjete za pravilnu primjenu poučavanja usmjerenog na polaznika nije lako ispuniti u sadašnjim pisanim i nenapisanim normama. Naposljetku, rezultati pokazuju kako tradicionalni stilovi poučavanja, koji postoje u različitim znanstvenim područjima, i dalje prevladavaju.

KLJUČNE RIJEČI

stilovi poučavanja, usmjerenost na polaznika, visoko obrazovanje, *PALS*

NEIZRAZITA GENETSKA KONTROLA BESPILOTNIH KVADKOPTERA

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SAŽETAK

Rad predstavlja novu metodu neizrazite identifikacije za dinamičko modeliranje bespilotnih kvadkoptera. Metoda se temelji na posebnoj parametrizaciji prethodnika neizrazitih sustava koja daje neizrazite podjele prethodnika. Metoda parametarkog reprezentiranja prethodnika, iskazana neizrazitim pravilima, osigurava zadržavanje predefiniranog lingvističkog poretka te osigurava nepromjenjivost neizrazite particije tijekom neuvjetovanog procesa optimiranja pristupom hibridne evolucije i pristupom gradijentnog pretraživanja. U jednadžbama gibanja komponente derivacije prvog reda određene su pomoću Christoffelovih simbola. Derivacije za neizraziti sustav upotrijebljene su za modeliranje Coriolisovog učinka te giroskopskih i inercijalnih članova. Nelinearni parametri podvrgnuti su početnoj, globalno evolucijskoj shemi optimiranja i fino podešeni metodom lokalnog gradijentnog pretraživanja. Rezultati simulacije rada predviđene nove metode identifikacije dinamičkog modela kvadkoptera vrlo su perspektivni.

KLJUČNE RIJEČI

kvadrotorna bespilotna letjelica, neizraziti sustav, neuvjetovano optimiranje, genetski algoritmi, gradijentno pretraživanje

SINTEZA REGULATORA BESPILOTNE LETJELICE S ČETIRI ROTORA

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SAŽETAK

Regulirani dinamički model quadkoptera služi za ispitivanje ponašanja i provjeru upravljačkih algoritama prije njihove implementacije na eksperimentalni postav quadkoptera. Cilj je projektirati sustav upravljanja koji će u kombinaciji s dinamičkim modelom dobro obavljati zadane zadatke, koji će uz određene preinake biti primjenjiv za više upravljačkih algoritama i koji će biti lako primjenjiv na eksperimentalni postav quadkoptera. U prvom dijelu opisano je projektiranje upravljanja. Jednadžbe dinamike pojednostavljene su uz određene pretpostavke te su kao takve korištene za sintezu regulatora. Budući da je quadkopter podupravljan i dinamički nestabilni sustav, upravljanje je podijeljeno na unutarnju i vanjsku regulacijsku petlju. U drugom dijelu opisan je upravljački algoritam PI-D koji je primjenjen na pojednostavljeni dinamički model quadkoptera. U unutarnjoj regulacijskoj petlji regulirana je visina, kutovi valjanja, poniranja i zakretanja quadkoptera. Izlazi iz unutarnje petlje su četiri upravljačke varijable quadkoptera. U vanjskoj petlji se reguliraju pozicije X i Y. Te dvije koordinate mijenjaju se promjenom kutova valjanja i poniranja. Rezultati ponašanja reguliranog sustava quadkoptera grafički su prikazani za tri vrste zadatka. Prvo je simulirano dostizanje željene točke u prostoru, a zatim praćenje referentne trajektorije. U trećem zadatku je prilikom praćenja trajektorije dodan periodički poremećaj. Simulacijama je prikazano da su greške pozicija u prihvatljivim granicama za regulirani sustav quadkoptera prilikom obavljanja različitih vrsta zadataka pod različitim uvjetima.

KLJUČNE RIJEČI

quadkopter, sinteza regulatora, unutarnja regulacijska petlja, vanjska regulacijska petlja, regulator PI-D

RAZVOJ VLASTITIH STRUKTURA I AKTIVNOG PRESLIKAVANJA

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SAŽETAK

U današnje vrijeme, uz sposobnost kontroliranja uobičajenih stresnih uvjeta na poslu, javlja se potreba istraživanja mentalnih kapaciteta kojima se medicinsko osoblje prilagođava novoj vrsti stresa – nesigurnosti zaposlenja.

Težište rada je na razvoju vlastitih struktura kao osobnih odrednica i njihove uloge u preslikavanju. Cilj rada je određivanje uloge vlastitih struktura u aktivnom preslikavanju nesigurnosti zaposlenja. Pretpostavljeno je kako narastajuća integracija vlastitih struktura vodi na narastajuću uporabu strategije aktivnog preslikavanja. Percepcija nesigurnosti zaposlenja mjerena je skalom percepcije nesigurnosti zaposlenja (Knežević i Majstorović, 2013). Upitnik funkcioniranja ega (Majstorović, Legault i Green-Demers, 2008) korišten je za evaluaciju vrsta funkcioniranja ega, dok je preslikavanje izvrjednjeno skalom kibernetičkog preslikavanja (Edwards i Baglioni, 1993).

Hipoteza je testirana metodom multivarijantne regresijske analize koja je postavljena s kriterijima samo-regulacije i strategije aktivnog preslikavanja. Za model e dobiveno $F(3, 306) = 26,73, p < 0,001$, te su sva tri prediktora značajna. Prediktori su bili u skladu s očekivanjima – Integrirana i ego-istražujuća osobnost su bili pozitivni prediktori ($\beta = 0,35, p < 0,001$ i $\beta = 0,16, p < 0,01$, redom), dok je bezličnost izdvojena kao negativni prediktor ($\beta = -0,13, p < 0,05$). Rezultati pokazuju kako razvoj vlastitih struktura predstavlja značajni prediktor aktivnog preslikavanja kod medicinskog osoblja suočenog s nesigurnošću zaposlenja.

KLJUČNE RIJEČI

vlastite strukture, nesigurnost zaposlenja, preslikavanje

SADAŠNJA UPORABA PRINCIPA KOMPONENTI ZA RAZVOJ MREŽNIH APLIKACIJA POMOĆU OKRUŽENJA: PREGLED LITERATURE

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SAŽETAK

Razvoj softvera temeljen na komponentama potala je vrlo popularna paradigma u mnogim granama programiranja. U ranoj fazi tehnologije Web 2.0, to je bio popularan način razvoja mrežnih aplikacija. Iz analiziranih radova, od navedenog perioda do danas, donekle se smanjila primjena tehnika temeljenih na komponentama u razvoju mrežnih aplikacija. Međutim, aktualni razvoj ukazuje na njihov povratak. To je prvenstveno vidljivo iz radne grupe W3C za mrežu po komponentama. U radu želimo istražiti sadašnje stanje razvoja mrežnih aplikacija komponentnim pristupom. Prvenstveno nas interesira na koji se način komponente koriste, koja se razvojna okruženja koriste za razvoj komponenti, za koje domene je mrežni razvoj temeljen na komponentama najpopularniji i uspješan i sl. Koliko sadašnjih okruženja za razvoj mrežnih aplikacija izravno upućuje na pristup temeljen na komponentama? Za odgovor na ovo pitanje pretražili smo dostupnu literaturu.

KLJUČNE RIJEČI

razvoj temeljen na komponentama, *CBD*, mrežne primjene, *www*, okruženja

MANUSCRIPT PREPARATION GUIDELINES

Manuscript sent should contain these elements in the following order: title, name(s) and surname(s) of author(s), affiliation(s), summary, key words, classification, manuscript text, references. Sections acknowledgments and remarks are optional. If present, position them right before the references.

ABSTRACT Concisely and clearly written, approx. 250 words.

KEY WORDS Not more than 5 key words, as accurate and precise as possible.

CLASSIFICATION Suggest at least one classification using documented schemes, e.g., ACM, APA, JEL, PACS.

TEXT Write using UK spelling of English. Preferred file format is Microsoft Word. Provide manuscripts in grey tone. For online version, manuscripts with coloured textual and graphic material are admissible. Consult editors for details.

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