BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF BUSINESS AND MANAGEMENT

Perspectives of Business and Entrepreneurship Development in Digital Transformation of Corporate Business

Economic, Management, Finance and System Engineering from the Academic and Practioners Views

PROCEEDING OF SELECTED PAPERS

April 30, 2019, Brno, Czech Republic

17TH INTERNATIONAL SCIENTIFIC CONFERENCE

PERSPECTIVES OF BUSINESS AND ENTREPRENEURSHIP DEVELOPMENT IN DIGITAL TRANSFORMATION OF CORPORATE BUSINESS

ECONOMIC, MANAGEMENT, FINANCE AND SYSTEM ENGINEERING FROM THE ACADEMIC AND PRACTIONERS VIEWS

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PREFACE

It is the honour for us to edit the Proceedings of selected papers presented in the 17th International Scientific Conference Perspectives of Business and Entrepreneurship Development: Digital Transformation of Corporate Business, held on April 30, 2019, Brno, Czech Republic.

The Faculty of Business and Management, Brno University of Technology highly promotes international research cooperation. The regular Scientific International Conference offers an opportunity for academics to present their research works. The primary goal of the 17th International Scientific Conference was to provide a unique platform to facilitate the exchange of leading ideas among academics and practitioners in the field for effective advancement of knowledge in the field of economic, management, finance and system engineering from the perspective of digital transformation. This was achieved through multidisciplinary presentations and discussions of current problems and conditions of business and entrepreneurship in the Europe and the World. The honorary patronage over the conference took the dean of Faculty of Business and Management, Brno University of Technology Ass. prof. Ing. et Ing. Stanislav Skapa, Ph.D.

The Program Committee of Scientific Conference assessed totally 100 submissions of international authors affiliated with universities in 17 countries, which confirms a long-lasted international recognition of the Conference. A total of 49 papers and abstracts has been peer reviewed by the renowned team of reviewers.

As the editors of this Proceeding, we are glad to see variety papers focusing on the perspectives of business and entrepreneurship development. Out of 49 submissions, 31 papers (acceptance rate 63,26%) have qualified for the approval of the Scientific Program Committee and for presentation at the Conference scientific sessions and high quality research papers (selection rate 36,74%) have been selected to the Proceeding of selected papers.

Special thanks are to all our international partners, representatives of the companies, reviewers, the members of international scientific program committee and all members of organisational committee. We would like to thank all who contributed in every process to make this Proceeding actualized.

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INTRODUCTION

Dear conference participants,

I would like to take this opportunity to cordially welcome you at the 17th International Conference of the Faculty of Business and Management, Brno University of Technology. It is a traditional event / conference the origins of which date back to the beginning after the foundation of the faculty.

The primary goal of the conference is to provide a unique platform to facilitate the exchange of leading ideas among academics and practitioners in the field for effective advancement of knowledge in the field of economic, management, finance and system engineering from the perspective of challenges to business and entrepreneurships. This will be achieved through multi-disciplinary presentations and discussions of current problems and conditions of business and entrepreneurships in the Europe and the World.

Approximately 150 guests will come to Brno in total, out of whom more than one third foreign guests from about 20 countries from around the world. A large part of the guests will also be representatives of companies, which is the intention of this year, focused on the current and discussed topic of digital transformation of companies. The conference will feature the presentation of projects carried out by the faculty: the results of the international project KA203: Strategic Partnerships for Higher Education – CHEDTEB: Collaboration in Higher Education for Digital Transformation in European Business, as well as the key ideas and intention of the new TA CR project reg. No. TL02000215 DIGITAL TRANS MSP: Digital Transformation for Business Model Innovations of Small and Medium Enterprises in the Czech Republic.

I am very pleased with the wide interest in this conference. It should be emphasised that the conference provides a natural platform for sharing scientific knowledge and exchange of experience with industry and business representatives, which contributes to the active development of our bilateral cooperation with practice, being an integral mission of the conference.

The conference discussions will feature not only scientific topics, but also the exchange of pedagogical experience and knowledge, which will help to develop contacts between individual participants. I am convinced that establishing new contacts and strengthening the existing ones is an integral part of this conference, which will be supported by the social activities of the accompanying programme of the conference.

I wish the participants of the 17th International Conference of the Faculty of Business and Management hearing successful and interesting papers, establishing new contacts, and obtaining ideas for their creative work.

Stanislav Skapa

Dean

CONTENT

ABOUT CONFERENCE 9
Further Publication Opportunities 10
Programme Committee 11
Reviewers 13
Organising Committee 15
Section 1 – Economics in Digital Transformation 17
Czech regions: Relationship between Research and Development expenditure and economic strength 19
Comparison of Neural Networks and Regression time series in Predicting Development of EU Export to PRC 31
Section 2 – Finance in Digital Transformation 43
The reaction of the Slovak Financial Administration to transfer pricing issues 45
Key Performance Indicators and the Balanced Scorecard Approach in Small and Medium-Sized Enterprises: A Literature Review 57
Challenges in Digital Product Development at Latvian Commercial Banks .. 67
Typology of Statutory Cities in the Czech Republic from the Perspective of their Indebtedness and Population 77
Expenditures for Employees within Local Unit Budget 85
Innovation Scorecard in an Agile Software Development Working Environment 95
Digitalisation impact Measuring on claim Management for the Insurance Sector 107
Section 3 – Management in Digital Transformation 117
Leadership Metaphors as expressions of Implicit Leadership Theories in Germany and the Czech Republic 119
Challenges and use of virtual tools in teamwork 131
Current situation and trends in creating corporate strategy 141

Value Creation Process for Digital Business and Entrepreneurship: New Challenges for Human Intellectual Capital in the digital World..... 149

The digital Transformation in Supply Chain 157

Section 4 – Systems in Digital Transformation 169

Maple Application in Economic Disciplines 171

Decision-Making Process Using Neuro-Fuzzy Model for Capital Market... 177

Taylor Approximation of Multilateral Resistance Term with Unilateral Variable in STATA 185

Mathematical and numerical study of a SIR epidemic model on network with standard incidents 191

ABOUT CONFERENCE

The honorary patronage over the conference took the dean of the Faculty of Business and Management, Brno University of Technology associate prof. Ing. et Ing. Stanislav Skapa, Ph.D.

Conference Theme: "Perspectives of Business and Entrepreneurship Development in Digital Transformation of Corporate Business,, Economics, Management, Finance and System Engineering from the Academic and Practitioners Views. The aim of this year's conference is to provide an expert platform for sharing ideas and discussing opinions between the academics and practitioners in the sphere of new trends and perspectives of business development and entrepreneurship influenced by the digital era. Conference Sections:

Section 1: Economic in Digital Transformation

Section 2: Management in Digital Transformation

Section 3: Finance in Digital Transformation

Section 4: Systems in Digital Transformation

Section 5: Universities in Digital Transformation

Special Section: Toolbox for Digital Corporate Transformation Management (supported by CHEDTEB project)

The primary goal of the conference is to provide a unique platform to facilitate the exchange of leading ideas among academics and practitioners in the field for effective advancement of knowledge in the field of economic, management, finance and system engineering from the perspective of challenges to business and entrepreneurships. This will be achieved through multidisciplinary discussions of current problems and conditions of business and entrepreneurships in the Europe and the World. Major highlights of the conference would be creating of the platform for network and communication with distinguished entrepreneurs, managers and traders.

This conference will feature competitive papers, plenary session, panel discussion and sections roundtable. Submissions will be subjected to a blind review process and will be published in the refereed Conference Proceedings „Selected papers: Perspectives of Business and Entrepreneurship Development in Digital Transformation of Corporate Business: Economic, Management, Finance and System Engineering from the Academic and Practioners views", which will be applied for covering by abstracting/indexing services: Thomson Reuters Conference Proceedings Citation Index (ISI).

FURTHER PUBLICATION OPPORTUNITIES

On the basis of agreed cooperation with editors of the scientific journals there will be offered an opportunity for the authors of high quality contributions to publish extended versions of their contributions in journal indexed in reputable databases:

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https://ortus.rtu.lv/science/en/series/3	ISSN 1407-7337
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http://www.inzeko.ktu.lt/index.php/EE	ISSN 1392-2785
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SECTION 1
–
ECONOMICS IN DIGITAL TRANSFORMATION

Czech regions: Relationship between Research and Development expenditure and economic strength

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Abstract

Purpose of the article The economic strength of a country can be measured through the GDP. R&D expenditure is one of the economic indicators, which influence the economic performance of the country. The difference in the level of GDP and R&D expenditure should be kept in sustainable limits for the welfare of the country as a whole. The analysis of the relationship between GDP and R&D expenditure can serve as the basis for the fiscal policy on a regional level.

Methodology/methods To test the autocorrelation of time series, the Durbin-Watson test used. The correlation analysis found to be suitable for searching for the influence of the selected variables.

Scientific aim The aim of the article is to analyse the interdependence of R & D expenditure and of the GDP of individual regions of the Czech Republic in the period 2005 – 2017.

Findings The Durbin Watson test excluded the autocorrelation of the selected variables. Authors performed statistical testing and correlation analysis. The correlation analysis did not confirm the correlation between R & D expenditure and regional GDP. An only slightly positive correlation was identified in the Central Bohemia region with a GDP + 1 prediction indicator. It is clear from the results that the selected indicators are almost independent of each other.

Conclusions The relationship R & D expenditure and GDP is seen as a source of growth in the standard of living of the population in many professional works. This research did not show the interdependence of R & D expenditures and GDP in the regions of the Czech Republic. Despite the fact that delays of individual indicators were observed by one or two years respectively. The dependence of R & D expenditure growth on GDP was not confirmed.

Keywords: correlation, GDP, R & D expenditure, Czech Republic

JEL Classification: O38, R12, R58

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Introduction

The Lisbon Strategy (European Committee, 2000) and the European Union (EU) 2020 strategy (European Commission, 2014) are the EU's agencies for growth and jobs for the current decade. They emphasize smart, sustainable and inclusive growth as a way to overcome structural weaknesses in Europe's economy, improve its competitiveness and productivity and underpin a sustainable social market economy. The strategies targets are valid for all EU members. We are interested in the Czech Republic regions and their economic strength. The Czech Republic is enjoying an economic upswing. Following a shallow recession in 2012 and 2013, real GDP grew by 9.5 % per year on average between 2015 and 2017. Rapidly increasing wages are projected to have supported solid household consumption growth in 2017. The Czech economy is shifting towards more knowledge-intensive activities, with increased business R&D investment, mainly through foreign direct investment FDI. The country saw some of the strongest EU growth in high-tech and medium-high-tech manufacturing and know-ledge-intensive services sectors, in terms of share of value added. Business expenditure on R&D (BERD) has increased from 0.7% of GDP in 2008 to 1.03% of GDP in 2017 (61.1 % of total R&D). There are significant inequalities between regions.

The territorial economic and social inequality is one of the most fundamental factors in the development of the economy. Of course, the analysis of territorial inequalities has high priority in the EU. With the increasing number of EU Members, the economic and social inequalities were also changing. According to the current dates of the Eurostat (European Commission, 2018), there is a 50-fold difference between the richest Inner London - West and the poorest Severozapaden, Bulgaria in terms of GDP per capita. Regions of the Czech Republic are better off. The difference was in 2004 between the richest Inner London and the Czech poorest Severozápad region only 19.68-fold, in 2016 decreased only to 17.28-fold. The Czech richest region is Praque. The difference between the Inner London and Prague region was in 2004 7.56-fold and in 2016 5.97-fold. Why do some regions grow continuously for many years whereas others stagnate? The theoretical breakthrough in answearing this and similar questions started by Schumpeter (1912), Dorfman et al. (1986) and Romer (1986, 1990). Following the endogenous growth and neoclassical growth theories, Research and Development (R&D) and technological advances are believed to the major driver of economic growth. How exactly new knowledge translates into preferable economic performance by regions described the growth theories nor found an unequivocal empirical explanation (Maradana et all., 2017).

In the recent years, many researchers and policymakers have increasingly paid attention to investigating the relationship between regional outcomes, R&D expenditure, Innovation and Entrepreneurship (Ulku, 2004; Wong et al., 2005; Tsvetkova et al, 2014).

What affects the economy in multiple channels, such as global competitiveness, economic strength and growth, quality of life, infrastructure development, employment, trade openness, and hence, spawns high economic growth? Many studies mostly focus on the impact of innovation on economic growth, indicating the supply-driven approach of innovation-growth nexus. But in reality, it is the economic growth that can also increase the level of innovation in the development process. Pradhan et al. 2016) discussed feasibility of bidirectional causality between innovation and economic growth. Hence, the main objective of this paper is to examine the relation-ship between innovation and economic strength. In sum, we would like to assess the importance of innovation-economic strength linkage, by investigating whether the level of innovation has contributed to economic strength, or whether the extension of the innovation is simply a consequence of economic strength. The main contribution of the study is twofold. First, we specifically assess the importance of R&D expenditure on economic growth, by investigating whether the innovation activities have contributed to economic growth and economic strength, or whether the expansion of innovation activities is simply a consequence of rapid economic growth. Second, our data set is comprehensive (i.e. 2005–2017) and compile the entrance EU period, the world crisis years and period of high economic growth in Czech regions.

The rest of the paper is sketched as follows. The second part presents the theoretical basis and literature review. The „Data structure and methods“ section describes the variables, data and used methods. The „Result“ section presents the results of statistical calculations. The „Discussion“ section describes our discussion. Finally, we summarize and conclude in the „conclusion“ section.

1 Theoretical basis and literature review

The first issue of the relationship between wealth, investment and economic strength was presented by Giffen (1892). On the occasion of 100 anniversary of the invention of Edison's electric lamp was presented the strength

of the U.S. economy. In 1978 fewer patents were issued to U.S. residents than at any other time since 1964. The share of patents which the United States granted to nationals rose in 1978 to 37%, from 20% in 1964. The Japanese share alone rose from 1 to 10%. Science and technology is key to economic strength. It has estimated that technological innovation was responsible for 45% of the nation's economic growth from 1929 to 1969 (Banner, 1979). Accumulated wealth is only one element of economic strength. Creativity and innovation are real keys to America's economic strength. Innovation has generated the productivity that has accounted for half of the GDP growth over the past 50 years, argues Engler (2006). R & D is not a single major factor influencing the economic strength of the region. This is especially the impact of fiscal access. Malin (1989) argued that local governments in many of the region's metropolitan centres forecast their most serious fiscal imbalances in at least a dacade, raising the prospects of higher taxes, cutbacks in public services and reduced competitiveness against lower cost areas of the country. Many local government officials fear what economist have long acknowledged; a shrunken manufacturing base, dependence on the volatile financial and business sectors, and losses of industrial diversity. This susceptibility to economic unpleasantness.

Factors economic forces were examined in other regions. For example, Kazachstan's researchers identified the key competitive advantages of the Pavlodar region, which is a large industrial center of the Republic of Kazakhstan and has substantial economic strength. Competitive advantages of the region, including a rich natural resources potential, availability of a developed industrial and social infrastructure, high scientific and technical capacity, and the connecting role between Central Asia and Siberia, have been reviewed. Solid competitive ad-vantages for investing in the development of the region have been revealed. The authors have stated general positive factors that contribute to the expansion of the economic strength of the Pavlodar region and positively influence the sustainability of the development of the regional economy (Bayandin et al,2017).

The initial point of many growth theories is connected with a model of Solow (1956). This is known as the Solow-Swan model which considers long-run economic growth. The neoclassical production function - Cobb-Douglas form is a base of this model. This model i sone of the first that considered the impact of technological change on economic growth. The Solow-Swan model recognizes the significance of the positive impact of technology changes on economic growth, but it is considered exogenous. Modern developed economy gains more and more features innovative economy. This is related to the research, development, and implementation and uses innovation for growth in living standards. Innovation has become a decisive factor in the stable development of the country. Innovation was also emphasized by J.A. Schumpeter (1912). He argued that only entrepreneurs and their entrepreneurial ideas can bring innovations leading to technological progress. He adds that innovation is concentrated in larger cities where conditions for innovation activities are. Some researchers analysed the interaction between technological change, focusing on the role of technological innovations in the decline of mortality and fertility, across societies (Boserup, 1981; Rostow, 2001). The R&D was identified as the major component of economic growth and Romer (1986) based endogenous growth theory on investment in R&D activities. Romer (1990) and Grosman and Heplman (1991) confirmed the results of the model for most of the developer countries and argued that R&D expenditure are vital for economic growth. Innovation is an important source and inherent power which maintains sustainable economic development of a country or region, and an index which measures the economic strength of a country, and it is also a crucial embodiment of the core competitiveness of enterprise a company (Turečková, 2018).

The Europe 2020 strategy has also set a target for R & D. This is measured using the GERD indicator defined by Frascati Manual. The indicator provided is GERD (Gross domestic expenditure on R&D) as a percentage of GDP. "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications". A country's gross domestic expenditure on R&D (GERD) is broken down into four sectors of performance, which are expenditure by the business enterprise sector (BERD), the government sector (GOVERD), the higher education sector (HERD) and the private non-profit sector (Chung, 2015). GERD (Nevima, Kiszová, 2012) is an important driver of regions' economic strength. We will use the annual change in R & D expenditure for monitoring trends in the regions.

The other indicator, GDP per capita, is calculated as the ratio of real GDP to the average population of a specific year. GDP measures the value of the total final output of goods and services produced by an economy within a certain period of time. It includes goods and services that have markets (or which could have markets) and products which are produced by general government and non-profit institutions. It is a measure of economic activity and is also used as a proxy for the development in a country's material living standards. However, it is a limited measure

of economic welfare. For example, neither does GDP include most unpaid household work nor does GDP take account of negative effects of economic activity, like environmental degradation (European Commission, 2019a).

2 Data and Methodology

For the empirical analysis, we selected two variables: R&D expenditure, GDP per capita for the regions of the Czech Republic, for description of variables and regions see Tab. 1., Tab. 2. There are significant inequality, Expenditures for research and development cover basic research, applied research as well as experimental development, therefore fuelling one of the most powerful engines of Innovation. R&D Expenditure cover basic research, applied research as well as experimental development, therefore fuelling one of the powerful engines of Innovation. R&D Expenditure as a percentage of the GDP is the most commonly used measure of innovation, indicating the intensity of Research and Development of a region. R&D expenditure is an important enabling factor for human capital because it supports knowledge generation and skills development. On the other hand, highly skilled human resources are for the total EU's research and innovation capacity and competitiveness. The dynamism of creativity and adaptability of human resources to successfully deal with the most diverse tasks. GDP per capita reveals the accumulated productivity of the economy. As a measure of material prosperity, well-being, level of development, and so on, GDP per capita is a usually linked to competitiveness, therefore it was a natural decision to include it in the analysis as part of the economic pillar.

Table 1 Definition of variables

Indicators	Acronyms and period	Description
Gross Domestic Expenditure on R&D (GERD) as a percentage of GDP	GERD_2002-2017	Gross domestic expenditure on research and development (GERD) is the total intramural expenditure on research and development performed on the national level during a given period
Regional GDP	GDP_2002-2017	Regional gross domestic product (GDP) is a geographic breakdown of national GDP presented in nominal terms. Regional GDP provides an indication of the size and structure of regional economies and provides a benchmark for measuring changes to regional economies over time.

Source: CZSO, 2019a

The source of the data is the Eurostat database and CZSO database for the dependent and independent variables. The analyzed period was 2002-2017. The regions were created by the legislature in the year 2000. The name of the region is replaced by an abbreviation and the description is complemented by population development in the years 2002 – 2017, see Tab. 2. The decline in population in the period considered is obvious in the regions that have the lowest GDP R & D expenditure and low. An exception consists of the Olomouc Region and Zlin Region where R & D expenditure in the year 2017 increased significantly.

Table 2 Description of regions

Region NUTS 3	Acronyms	Population 2002	Population 2017
Prague	CZ010	1 170 571	1 286 554
Central Bohemian Region	CZ020	1 144 071	1 345 764
South Bohemian Region	CZ031	625 712	639 180
Pilsen Region	CZ032	549 618	579 228
Karlovy Vary Region	CZ041	304 588	**296 106**
Usti Region	CZ042	822 133	**820 937**
Liberec Region	CZ051	427 563	440 934
Hradec Králové Region	CZ052	547 296	550 848
Pardubice Region	CZ053	505 285	517 243
Region Vysočina	CZ063	517 153	**508 664**
South Moravian Region	CZ064	1 123 201	1 180 477
Olomouc Region	CZ071	635 126	**633 133**
Zlín Region	CZ072	590 706	**583 039**
Moravian-Silesian Region	CZ080	1 257 554	**1 207 419**

Source: Own compilation, CZSO 2019b

The main method used in this research is the correlation analysis method. It determines whether regional GDP, GDP per capita, and R & D expenditure depend on each region. The correlation analysis for GDP indicators, GDP per capita and R & D expenditure is used in many types of research (see Klímová and Žídek, 2015; Maradana et al., 2017, Dima et al., 2018). It is well known that for linear autoregressive models with autocorrelated residuals, the least squares estimator is asymptotically biased, and therefore the estimated model is not the correct one. Consequently, to ensure a good interpretation of the results, it is necessary to have a powerful tool allowing to detect the possible autocorrelation of the residuals. The well-known statistical test of Durbin-Watson was introduced to deal with this question, and more specifically, for detecting the presence of a first-order auto-correlated noise in linear regression models, firstly and for linear autoregressive models secondly. To the best of our knowledge, no such serial correlation statistical test is available for controlled autoregressive processes (Bercu, 2014). It will be used the serial correlation test, based on the Durbin-Watson statistic. It validates the hypothesis that residues of e_i are mutually uncorrelated. We will test the hypothesis H_0: $p = 0$ against H_1: $p \neq 0$ engine at significance level α and we count the test criterion.

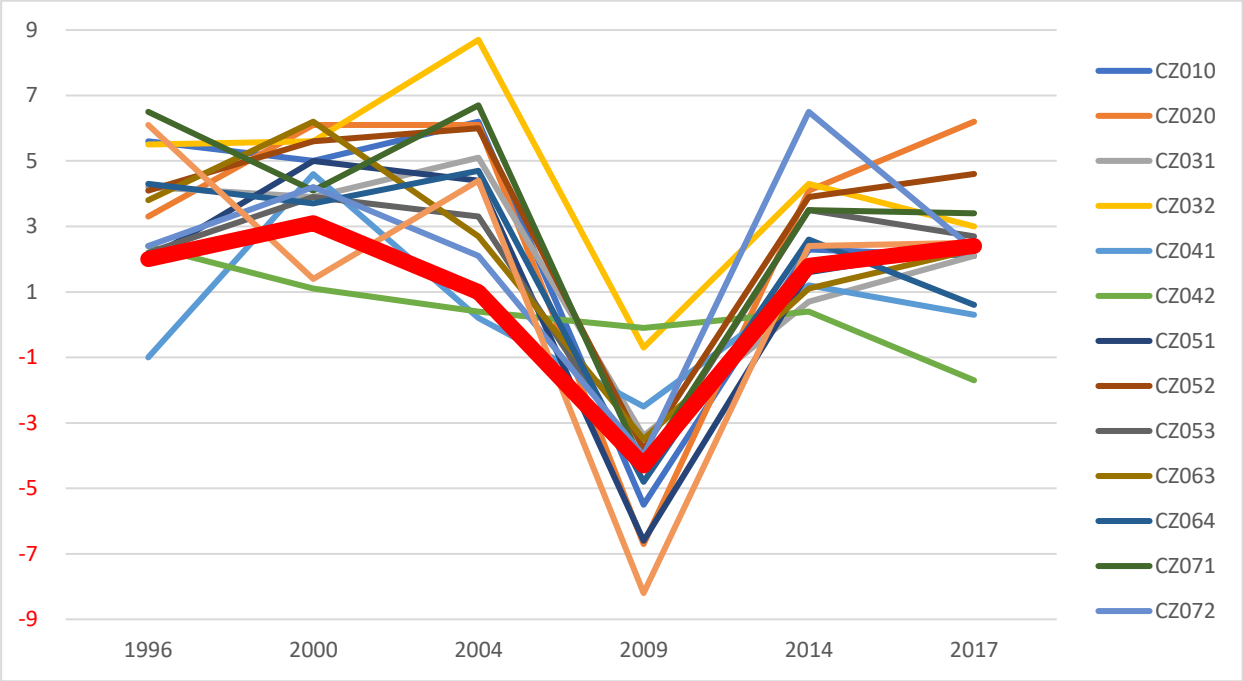
$$D = \frac{\sum_{i=2}^{n} (e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2}$$

When D = 2, the correlation is zero. When is the strong positive correlation, D is approaching 0, when is the strong negative correlation is D close 4. All the statistical analyses in this research will perform using the statistical software Statistica 12.0 and R software.

3 Results

The Czech Republic as a one of Central and Eastern Europe (CEE) country is in a long process of transforming into knowledge-based economies. After political changes, the Czech Republic began its transformation from the previous level, currently in the level of economic development, government priority as well as living standard. The economic growth was driven by domestic consumption before 2008, claimed Kravtsova and Radosevic (2012). The current government and regional government policy is closely focused on R&D-based growth and do

not address the key drivers of technology accumulation and economic growth. I this recent re-search we have analyzed the relationship between regional GDP, GDP per capita and R&D expenditure among the regions in the Czech Republic. The first step of our analysis was to count the increment for each time series.



Source: Own compilation, Eurostat, 2018 and CZSO 2019a

Figure 1 GDP growth rate in the Czech regions and EU

GDP created in the region is not a suitable unit for interregional comparisons. It is necessary to eliminate different population numbers in individual regions, inflation, etc. GDP growth compared to the EU average used only for illustrative graphical comparisons, see. Fig. 1. It is seen that in the long term, the Central Bohemian Region is the most stable and the average growth rate is 3.95%, Prague is second. The Karlovy Vary region, with an average growth rate of 0.17%, is in the last place. All Czech regions affected by the world crisis in the years 2008 – 2009. Six regions have a higher GDP growth rate than the EU average, as seen in Fig. 1. The least affected by the economic crisis was the Usti region in 2009. However, its trend has a downward trend. The smallest growth rate is recorded in the Karlovy Vary Region; the sharpest growth is evident in the Prague region. In order to compare the interdependence of the development of the R&D expenditure and GDP variables, it is necessary to have a data line for many years. The pace of growth of individual variables was used to eliminate the national currency. This relationship, of course, does not imply the conclusion that one variable was causing the second and the second as a result. It cannot be concluded from these results that higher GDP of the region, higher per capita GDP in the region. Or conversely that a higher R & D expenditure means that the region is capable of creating a higher GDP, or that increases the standard of living of the population. This relationship examines using the correlation of selected variables. It is a time series and it is, therefore, appropriate to make the Durbin-Watson test. R&D expenditure and GDP year on year changes present Table 3. If the period of the year's decline indicates it in red colour.

Table 3 shows that GDP development in the region does not reflect the development of R & D expenditure. Higher variability we see in R & D spending compared to GDP growth. Annual GDP change ranges from -4.41% (Central Bohemian Region in 2009) to 14.49% (Moravian-Silesian Region in 2004). Year-on-year change in R & D expenditures has a significantly higher amplitude. R & D expenditure is not so dependent on the economic situation. Czech Republic's accession to the EU in 2004 marked the accession to the Lisbon objectives and changing priorities in connection with the commitment to increase R & D spending. One-off actions in the form of various grant opportunities and an inflow of foreign direct investment, which often meant the transfer of innovation centers to the Czech Republic, are also significant. R & D expenditure decreased in the Zlin region

since 2002, so the increase in one-off increase in R & D expenditure meant growth of 99.77% in 2005. Significant is the fact that the South Moravian Region, as the only one, shows steady growth in R & D expenditure, indicating its outstanding position in research, development and innovation. It is a region of many innovation centers and incubators. Significant is the support of the region's government in the form of innovative vouchers.

Calculation of increases in the regions was subjected to statistical analysis. For the results of the Durbin-Watson statistical test, see table 4. Autocorrelation for time series of 16 interval values (1.36092; 2) means that we assume the H0 hypothesis when the time series is not correlated. As the results did not show positive auto-correlation in the regions, the correlation between GDP and R & D expenditures in the period 2002 - 2017 was made in all regions of the Czech Republic.

Table 4 Statistical tests

	DW	t	p
CZ010	1,38	2,57	0,022
CZ020	1,66	3,68	0,0024
CZ031	1,37	3,03	0,009
CZ032	1,71	4,52	0,0005
CZ041	1,38	3,32	0,005
CZ042	1,97	3,48	0,0037
CZ051	1,47	2,54	0,0237
CZ052	1,41	3,32	0,0051
CZ053	1,39	2,88	0,012
CZ063	1,42	5,08	0,0002
CZ064	1,39	3,74	0,002
CZ071	1,69	4,77	0,0003
CZ072	1,38	3,83	0,0018
CZ080	1,43	3,31	0,0051

Source: Own compilation

After the Durbin Watson test, we performed a correlation analysis in STATTIATICA 12 software. We tested the dependence of GDP against R & D Expenditure by correlation analysis. We have also calculated variants for leading indicators. So when one pointer overtakes the second for one year and also two years. For the results see Table 5.

Table 5 Negative correlation coefficient values

	GDP/R&D	GDP+1/R&D	GDP+2/R&D	GDP/R&D+1	GDP/R&D+2
CZ010	0.51	0.44	0.27	**0.12**	0.06
CZ020	0.00	0.58	0.16	0.06	**0.12**
CZ031	0.46	0.48	0.30	0.50	**0.04**
CZ032	**0.20**	**0.26**	0.03	0.09	**0.20**
CZ041	**0.07**	**0.50**	0.08	**0.37**	**0.10**
CZ042	0.08	0.06	0.29	**0.22**	**0.16**
CZ051	0.26	**0.15**	0.00	0.20	**0.28**
CZ052	0.37	0.05	0.34	**0.18**	**0.00**
CZ053	0.12	0.21	0.02	**0.08**	**0.26**
CZ063	**0.32**	**0.25**	0.38	0.10	**0.10**
CZ064	0.17	0.14	0.02	**0.06**	**0.38**
CZ071	**0.13**	**0.38**	0.12	0.10	**0.24**
CZ072	0.22	0.19	0.13	**0.14**	**0.17**
CZ080	**0.04**	0.34	**0.25**	**0.15**	**0.35**

Source: Own compilation

It is clear from the results that the selected indicators: GDP of the region and R&D expenditures of the region do not depend on the long term. Most of the correlation coefficients are closer to Zero. Only for the Prague region and the Central Bohemia has a coefficient of value> 0.50. Here we can think of moderate dependencies. The data published in Table 3 suggest this. Firstly, there has been a drop in R & D expenditure and consequently a decline in GDP growth. From an overall impression of this dependency cannot be regarded as relevant. Inter-dependence has not been confirmed in either of the leading indicators. When selecting a lead R & D expenditure + 2 years, the correlation coefficient is negative.

4 Discussion

R & D support is included among strictly monitored economic indicators in developed countries. The Czech Republic ranks GERD among the first half of the EU member states. In 2017, the GERD was 1.79%. Its economic strength is increasing, but it varies greatly between regions. A correlation analysis was used to determine the relationship between R & D expenditure of the region and GDP of the region that measured economic strength. The monitored time series was the longest possible. The emergence of contemporary regions is dated to 2001. This research used data in the time series 2002-2017. The Durbin-Watson test was used to exclude autocorrelation. Autocorrelation isn't positive.

Comparing year-on-year R & D expenditures and GDP growth, no positive correlation was observed. Also, the positive correlation was eliminated with the use of leading indicators, the delay of one or the d_t variable. Only the negative correlation, excluded by Prague, was observed for the delay of R & D expenditures by two years. For results, see Table 5. It is not possible to clearly identify the relationship between R & D expenditure and the economic strength of the region. More accurate results and possible demonstration of mutual relationship is the topic of further research. In order to clarify mutual influence, it is possible to use R & D expenditures in the business sector only, the economic level measured GDP per capita, recording the knowledge capital of the measured level of tertiary education. This is one of the Europe 2020 Strategy targets.

Conclusion

The level R&D expenditure and structure of innovation should not be ignored because it plays an imperative role in stimulating economic growth (Pradhan et al. 2016) and economic strength (Kiszová and Nevima, 2012). This paper explored the correlation analysis between R&D expenditure and regional GDP for the 14 Czech regions using time series data from 2002 to 2017. The economic strength of the country is based on the economic strength of its regions. The pivotal message from our study for the policymakers and academicians alike is these implications drawn from research on economic strength growth that disregards the dynamic interrelation of the two variables will be imperfect. It is the conjoined back-and-forth relationship between innovation and economic strength growth that builds our study and guides future research on this topic.

The aim of the article was to assess the interdependence of R & D expenditure and of the GDP of individual regions of the Czech Republic in the period 2005 – 2017. Correlation analysis of applied research with precocious indicators. Our calculated evidence is based on annual data from 14 regions of the Czech Republic. The economic strength of regions and R & D expenditure increased during the reference time period. But interdependence between them has not been observed. Neither prediction of individual indicators has been confirmed.

The influence may be the fact that R & D spending relative to GDP is relatively low. Most active is in the Central Bohemia region in the year 2015 (2.85%). The low percentage of R&D Intensity each special-purpose increase R & D expenditure reflected more intensely. When we use the ignition advance indicators is also interdependence. From the calculations, it is impossible to infer that the R & D support has a positive effect on the economic strength growth of the region. The inclusion of different factors may affect our main findings and this could be the subject of future research.

Additional, the other limitations do exist in this study. First, no indirect or complementary effects on the nexus between R & D Expenditure on economic strength growth; second, the findings are regulated to Czech regions only; third, exclusion of sector-wise impact of innovation activities an economic strength growth; and fourth small time-dimension of data, i.e. 2005 - 2017. Consequently, further study in these mutable areas can produce more inspiring and spontaneous findings to the nexus between R&D Expenditure and economic strength growth.

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References

BANNER, D. (1979). Patent system: A key to economic strength. *Business America (pre-1986)*. Washington: Superintendent of Documents, 2.

BAYANDIN, M. A., NARYNBAYEVA, A. S., ARYNOVA, Z. A., BAYANDINA, G. D., ALIMKHANOVA, R. K. (2017). Assessment of competitive advantages of the Pavlodar region and its economic strength. *Journal of Advanced Research in Law and Economics*, 8(2), 380-396.

BERCU, B., PORTIER, B., VAZQUEZ, V. (2014). *A Durbin-Watson serial correlation test for ARX processes via excited adaptive tracking*.

BOSERUP, E. (1981). *Population and Technological change: A study of longterm trends*. University of Chicago Press, Chicago.

CZECH STATISTICAL OFFICE. (2019a). *Gross Domestic Product in the areas and regions*. Retrieved from https://vdb.czso.cz/vdbvo2/faces/cs/index.jsf?page=vystup-objekt&pvo=NUC05-S5&z=T&f=TABULKA&skupId=706&katalog=30832&pvo=NUC05-S5#w=

CZECH STATISTICAL OFFICE. (2019b). *Population and vital statistics - territorial comparison*. Retrieved from https://vdb.czso.cz/vdbvo2/faces/en/index.jsf?page=vystup-ob-jekt&pvo=DEM04&z=T&f=TABULKA&skupId=527&katalog=30845&c=v3~9__RP2017MP12&&str=v77#w=

DIMA, A. M., BEGU, L., VASILESCU, M. D., MAASSEN, M. A. (2018). The Relationship between the Knowledge Economy and Global Competitiveness in the European Union. *Sustainability*, 10(6), 1706. Doi 10.3390/su10061706.

DORFMAN, R., SAMUELSON, P. A., SOLOW, R. M. (1986). *Linear Programming and Economic Analysis*. New York: Dover Publications.

ENGLER, J. (2006). Innovation is the key to economic strength. *Plant Engineering*, 60(3), 84.

EUROPEAN COMMISSION. (2010). *Europe 2020 strategy*. Retrieved from https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/framework/europe-2020-strategy_en

EUROPEAN COMMISSION. (2019a). *Real GDP per capita*. Retrieved from: https://ec.europa.eu/eurostat/web/products-datasets/product?code=sdg_08_10

EUROPEAN COMMISSION. (2019b). *Regional gross domestic* product. Retrieved from: https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=tgs00005.

EUROPEAN COMMITTEE OF THE REGION. (2000). *The Lisbon Strategy in short*. Retrieved from https://portal.cor.europa.eu/europe2020/Profiles/Pages/TheLisbonStrategyinshort.aspx.

GIFFEN, R. (1892). International Statistical Comparisons. *Publications of the American Statistical Association*, 3(18/19), 199-212.

CHUNG, D. (2015). R&D: EU's Progress Towards Europe 2020 Strategy. *Dice Report*, 13(3), 72-74.

KISZOVÁ, Z., NEVIMA, J. (2012). Usage of analytic hierarchy process for evaluating of regional competitiveness in case of the Czech Republic. *30th International Conference on Mathematical Methods in Economics*. SILESIAN UNIV OPAVA, SCHOOL BUSINESS ADMINISTRATION KARVINA, 402-407.

KLÍMOVÁ, V., ŽÍTEK, V. (2016). Inovační paradox v Česku: ekonomická teorie a politická realita. [Innovation paradox in Czech: Economy theory and politic reality] *Politická Ekonomie*, 63(2):147-166. Doi 10.18267/j.polek.994.

KRAVTSOVA, V., RADOSEVIC, S. (2012). Are systems of innovation in Eastern Europe efficient? *Economic Systems*, 36(1), 109-126

MALIN, S. (1989). Economic trends: strength and caution in the Northeast. *Business Credit*, 91(1), 48.

MARADANA, R. P. et al. (2017). Does innovation promote economic growth? Evidence from European countries. *Journal of Innovation and Entrepreneurship*, 6(1), 1-23.

PRADHAN, R. P., ARVIN, M. B., HALL, J. H., NAIR, M. (2016). Innovation, financial development and economic growth in eurozone countries. *Applied Economics Letters*, 23(16), 1141–1144.

ROMER, P. M. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy*, 94(5), 1002-1037. Doi 10.1086/261420.

ROMER, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, 98(5, Part 2), S71-S102. Doi 10.1086/261725.

ROSTOW, W. W. (2001). Population in the Twenty-First Century: The Limited Horizon of Public Policy. *Technological Forecasting and Social Change*, 67(1), 19–34.

SOLOW, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70(1), 65-94.

SCHUMPETER, J. (1912). *Theorie der wirtschaftlichen Entwicklung*. Leipzig: Verlag von Duncker & Humblot.

TSVETKOVA, A., THILL, J.-C., STRUMSKY, D. (2014). Metropolitan innovation, firm size, and business survival in a high-tech industry. *Small Business Economics*, 43(3), 661-676.

TUREČKOVÁ, K. (2018). Localization theory of regional development and agglomeration effects: A case study of the ICT sector in the Czech Republic. *Geographia Technica*, 13(1), 119-129.

ULKU, H. (2004). R&D, innovation, and Economic Growth: An Empirical Analysis. *IMF Working Papers*. (185), 1.

WONG, P. K., HO, Y. P., AUTIO, E. (2005). Entrepreneurship, Innovation and Economic Growth: Evidence from GEM data. *Small Business Economics*, 24(3), 335-350.

Appendix

Table 3 Development of GDP and R & D expenditure in regions of the Czech Republic

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CZ010	GDP	5,68	7,50	9,27	8,63	8,09	11,87	6,37	**2,54**	1,48	**1,41**	0,07	0,69	3,24	10,90	3,68	6,90
	R&D	0,54	15,97	11,73	17,95	16,07	20,55	**3,70**	**2,24**	**0,45**	9,86	7,62	5,98	12,53	12,08	**16,27**	15,93
CZ020	GDP	5,46	1,88	9,67	3,02	11,46	10,22	5,87	**4,41**	**0,08**	4,89	1,92	0,63	9,06	5,19	7,49	7,54
	R&D	5,08	**9,16**	3,24	38,22	15,70	15,85	**10,11**	1,20	5,61	5,53	5,16	45,54	1,65	1,13	11,86	28,47
CZ031	GDP	4,40	2,66	8,12	7,87	6,31	4,79	1,34	0,06	**0,67**	0,51	2,29	1,71	3,50	4,25	3,71	4,26
	R&D	4,97	21,02	11,58	40,08	7,39	3,99	10,17	4,80	2,58	3,75	15,69	**0,11**	**1,80**	7,08	6,81	2,86
CZ032	GDP	3,82	5,81	12,03	3,37	10,00	4,84	**0,57**	2,22	2,56	2,00	**2,04**	4,87	7,12	4,61	4,47	4,75
	R&D	27,17	**14,20**	17,44	34,67	18,08	3,42	28,12	**9,50**	43,49	36,89	20,30	9,36	14,61	**2,75**	**25,18**	4,86
CZ041	GDP	5,97	3,76	4,37	3,81	3,18	8,67	1,19	0,33	**2,01**	0,11	**0,84**	**0,48**	3,15	3,12	1,02	6,08
	R&D	13,67	18,77	5,01	**20,87**	**6,23**	8,34	**28,88**	57,83	23,70	17,30	64,16	**43,65**	31,84	34,01	**14,87**	22,08
CZ042	GDP	5,14	7,10	7,55	6,23	6,78	6,83	4,72	0,33	**2,66**	0,12	0,12	**0,41**	2,33	7,58	**1,28**	4,40
	R&D	**8,54**	31,88	**15,74**	15,38	**0,34**	15,98	19,28	**15,45**	6,45	15,37	33,34	**3,58**	12,13	**9,82**	**21,36**	4,57
CZ051	GDP	2,74	**3,43**	6,95	11,21	5,86	3,82	1,98	**3,51**	2,49	2,00	1,98	0,68	5,25	6,16	3,86	4,60
	R&D	5,21	6,52	6,27	27,44	26,13	**4,30**	13,21	**5,37**	1,14	28,21	53,69	**17,27**	10,47	**3,59**	5,30	9,08
CZ052	GDP	1,80	3,27	8,71	4,73	4,87	9,89	3,99	**0,69**	1,25	0,87	0,53	0,34	7,05	5,17	6,08	10,14
	R&D	**3,26**	18,68	50,19	**0,88**	13,13	22,42	**0,18**	19,28	**1,36**	13,53	0,04	12,50	8,72	**3,29**	**9,02**	19,03
CZ053	GDP	4,37	5,15	6,88	4,32	9,84	9,96	2,01	**3,32**	1,94	3,62	**4,52**	2,26	6,25	6,43	3,81	5,65
	R&D	2,68	24,47	7,96	18,13	15,35	3,44	**2,14**	**2,65**	14,55	15,69	12,58	**3,42**	1,48	**2,83**	**4,45**	9,60
CZ063	GDP	3,38	3,92	6,06	6,63	7,48	9,77	**0,26**	**0,75**	**0,73**	4,50	2,28	0,88	4,09	4,25	4,07	5,60
	R&D	33,31	0,92	23,73	33,36	**27,63**	**1,29**	39,54	0,22	6,75	4,99	18,16	25,86	29,41	2,31	**8,34**	**1,74**
CZ064	GDP	4,05	5,58	7,76	5,67	7,62	10,60	7,62	2,21	1,04	3,32	3,01	4,28	4,55	6,04	2,05	3,69
	R&D	2,94	10,41	14,06	17,39	16,57	18,92	9,12	13,83	5,82	31,38	30,85	10,52	5,11	4,04	**15,43**	3,46
CZ071	GDP	3,31	5,50	9,46	2,26	5,28	8,87	4,93	**2,23**	2,25	3,27	1,12	**0,06**	5,71	4,89	4,72	6,29
	R&D	18,55	3,76	16,15	30,22	**2,40**	15,04	5,43	13,24	**0,37**	32,26	66,77	**13,98**	10,34	**11,67**	**5,02**	18,84
CZ072	GDP	3,27	4,36	5,16	8,39	9,31	7,94	7,77	**2,22**	**1,04**	3,24	**0,21**	1,62	10,29	2,41	3,40	4,96
	R&D	80,63	**26,60**	**12,88**	99,77	9,64	**0,95**	**5,93**	**5,04**	14,76	18,53	9,40	**2,72**	21,95	**7,84**	3,49	27,99
CZ080	GDP	3,59	4,21	14,49	10,08	4,73	9,38	5,18	**5,90**	2,36	4,43	0,68	**2,81**	5,72	4,75	3,17	4,51
	R&D	**19,74**	71,70	**8,23**	**1,19**	6,80	18,53	**3,41**	14,58	1,79	58,87	**6,90**	**1,84**	14,55	0,77	**0,87**	**4,31**

Source: Own compilation, CZSO 2019

Comparison of Neural Networks and Regression time series in Predicting Development of EU Export to PRC

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Abstract

Purpose of the article This article focuses on the development of EU-China exports and trade in general, and also the advantages and disadvantages of regression analysis and neural networks in prediction.

Methodology/methods The data for the analysis are available at the World Bank websites, etc. For the purpose of the analysis, the data on the EU export to the People´s Republic of China (hereinafter referred to as "PRC") is used. The time-period for which the data are available is a monthly export for the period starting from January 2000 and ending in July 2018. In total, it is 223 input data. The unit is euro.

Scientific aim The objective of the contribution is to compare the accuracy of equalized time series by means of regression analysis and neural networks on the example of the EU export to the PRC.

Findings It can be stated that due to the high simplification of the reality it is not possible to predict extraordinary situations and their impact on the EU export to the PRC (at least not in the long term). Prediction in the order of days would be ideal; however, it is not possible to obtain data for such a short prediction.

Conclusions The EU export to the PRC can be identified based on statistical, causal and intuitive methods. These, however, provided only a possible framework of the monitored variable development. It is important to work with the information on a possible future development of political, economic or legal environment. Optically, in terms of the linear regression, the most suitable one appear to be the LOWESS curve. The second best possible is the curve obtained by the negative exponential smoothing least squares method and distance-weighting least squares method. In terms of neural networks, all retained neural structures appear to be applicable in practice, as there is no significant difference between them.

Keywords: neural networks, regression, time series, predicting development, export

JEL Classification: C22, C45

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Introduction

The PRC is now a trading accomplice with almost all nations since its opening up to international trade in the 1970's. Trade records between China and the EU is dated way back in the 1975 with the sole purpose of cooperating in strategic areas of improvement. Similarly, studies have proven that the EU import products from China more than the amount to which China imports from the EU. In 2001 China have become a member of the WTO and its membership have created a large effect on China's trade liberalization thereby leading to a decline of European's contribution to international trade from 37% to 31%, in conjunction with doubling of China's contribution from 5.5% to about 11% amid 2005 and 2015 (Karkanis, 2018).

Neural Networks and regression models were key studies subjects for over many years. Researchers over the years have had varying result in comparing neural networks and regression approaches. However, there is a famous call for in recent times for using neural networks in real time prediction because it requires less formal statistical training and it can implicitly detect complex non-linear relationships between dependent and independent variables.

1 Literature reviews

China´s export structure boom into the EU conforms to pattern of US tariff uncertainty (Mau, 2017). However, Goetz and Grethe (2010) highlighted that relevance of entry price system (EPS) has temporary nature for some product and a more general nature for some other products entering into the EU market from China. Accordingly, produces of fresh fruit and veggies from China benefit more from an improved market access in the EU.

Tao et al. (2018) explains that China's access to WTO in 2001 has spurred the growth of energy embodied in exports from China to the EU, at the same time as environmental policies issued by Chinese government since 2006 have pulled it down. The export sectoral shape changes and energy intake depth lower are key drivers of China's embodied power export modifications. Empirical result suggests that Chinese exports to EU have benefited from an unfair aggressive benefit through manipulation of its foreign money value (Cardoso and Duarte, 2017).

Karkanis (2018) applies a gravity model to asses elements underlying trade between China and EU for both export and import. His end result shows that the landlocked nature of several EU countries are useful for bilateral trade flow and other factors have brought positive contribution to EU-China bilateral trade expansion. Canofari and Ponte (2018) discovered that due to the increasing credit score gap in the Chinese economy and also the enduring political instability in some EU countries sent out a warning against the possibility of opening contagion channels between China and the EU. Trade and investment from China into the EU increased markedly in the years up to 2011, however fall since then, most notable for trade. Trade tensions and essential changes in the EU market explains some of the falls in trade between EU and China (Curran et al, 2017). Wang (2015) therefore emphasised an urgent need for the invention of new types of trade dialogues between China and EU as a necessary measure towards trade dispute settlement policy.

Gabriel (2008) expected an economically and politically reinforced China vis-a-vis the EU even as variations remain on the benefits losses relying at the ability of European nations to live united inside the EU. Delfa and Potvin (2016) concluded that neural networks provide more accurate and strong alternatives to regression approaches after performing direct comparison between neural networks and regressions by means of comparing their ability to predicts manual arm strength (MAS) same sets of development and validation MAS data. Merdun et al. (2005) on the other hand reported that regression performs insignificantly better than artificial neural networks (ANN) in their research. They further pointed out that ANN produces promising result in future research or application.

Tu (1996) highlighted a number of advantages of neural networks over regression models. Neural networks calls for less formal statistical education, implicitly locate complicated non-linear relationships between structured and impartial variables, and discover all possible interactions among predictable variables. However, they may be prone to overfitting, have black box nature, and create more computational burden as compare to regression models. Bilandzic et al. (2016) concluded that neural networks produce considerably higher classification accuracy of their model whilst incorporating all available variables. Vrbka and Rowland (2017) state that the preference of artificial neural networks is seen in relatively easy use for complex problems and forecast. This review focuses on the development of EU-China exports and trade in general, and also the advantages and disadvantages of regression analysis and neural networks in prediction.

Over the years, researchers have investigated and compared ANN and regression approaches using different data set. Some researchers found superior performance for neural network and others finding no overall difference and predicted performance. China exports more merchandise to Eurozone as compare to the EU exports to China. Due to an increase in Economic uncertainty in recent years EU-China trade is unhealthy as China benefits more from an unfair trade with the EU. Therefore, the need for new forms of trade dialogues between China and the EU as a necessary measure for a win-win trade corporation cannot be overemphasized.

The objective of the contribution is to compare the accuracy of equalized time series by means of regression analysis and neural networks on the example of the EU export to the PRC.

2 Data and methods

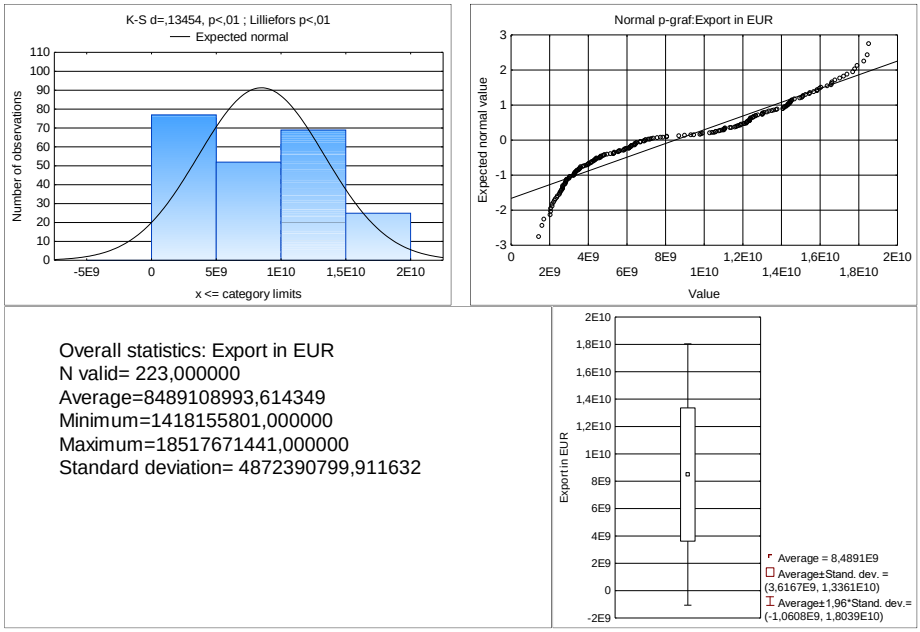
The data for the analysis are available at the World Bank websites, etc. For the purpose of the analysis, the data on the EU export to the PRC will be used. The time-period for which the data are available is a monthly export for the period starting from January 2000 and ending in July 2018. In total, it is 223 input data. The unit is euro. The data descriptive characteristics are given in Table 1.

Table 1 Data set characteristics

Samples	Month (Input variable)	Export in EUR (Output (target)
Minimum (Training)	36526.00	1.418156E+09
Maximum (Training)	43252.00	1.851767E+10
Mean (Training)	39916.52	8.475793E+09
Standard deviation (Training)	1949.82	4.793844E+09
Minimum (Testing)	36586.00	2.019653E+09
Maximum (Testing)	43282.00	1.778345E+10
Mean (Testing)	39702.30	8.020231E+09
Standard deviation (Testing)	2174.13	5.348653E+09
Minimum (Validation)	36951.00	2.296125E+09
Maximum (Validation)	43040.00	1.842305E+10
Mean (Validation)	40047.88	9.021341E+09
Standard deviation (Validation)	3096.16	6.655736E+09
Minimum (Overall)	36526.00	1.418156E+09
Maximum (Overall)	43282.00	1.851767E+10
Mean (Overall)	39904.26	8.489109E+09
Standard deviation (Overall)	1963.77	4.872391E+09

Source: Own processing

An important phenomenon is the development of the export over time. Figure 1 shows a graph of selected statistical characteristics, including the histogram of the input data.



Source: Own processing

Figure 1 Graph of basic statistical characteristics

The histogram indicates a higher data rate in the first three quartiles. For data processing, DELL´s Statistica software, version 12 will be used. Firstly, linear regression will be carried out. Subsequently, neural networks will be used for regression.

Linear regression will be carried out on the sample examined for the following functions: Linear, Polynomial, Logarithmic, Exponential, Distance weighting polynomial, Negative exponential smoothing polynomial.

First of all, correlation coefficient will be calculated, that is, the dependence of export on time. We will work with the significance level 0.95. Next, regression by means of neural structures will be carried out. We will generate multilayer perceptron networks and radial basis neural networks. The independent variable will be time, while the dependent variable will be the EU export to the PRC. The time series will be divided into three data sets - training, testing and validation. The first data set will contain 70% of the input data. Based on the training data set, neural structures will be generated. The two remaining data sets will contain 15% of the input data each. Both data sets will be used for verifying the reliability of the generated neural structure, or the model. The time series delay will be 1. In total, 10,000 neural networks will be generated, out of which 5 with the best characteristics. The hidden layer will contain at least 2 neurons (50 at most). In the case of radial basis function, the hid-den layer will contain at least 21 neurons (30 at most). For the multilayer perceptron network, the following distribution functions in the hidden and output layers will be considered: Linear, Logistic, Atanh, Exponential, Sinus.

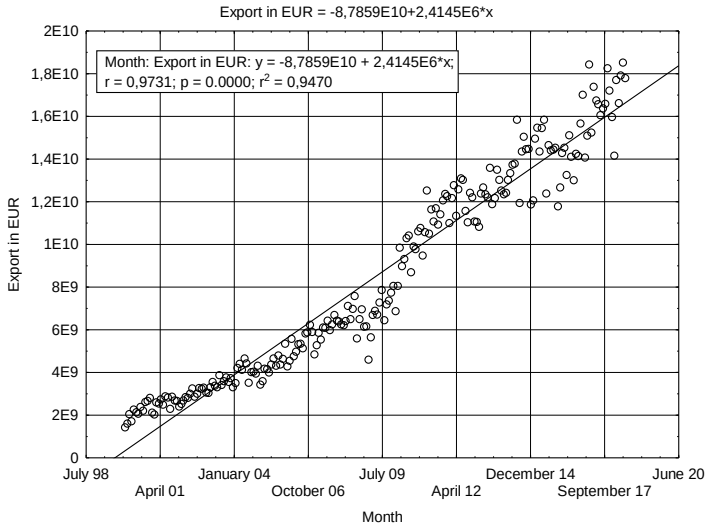
Other settings will remain default (according to the ANN tool – automated neural networks). Finally, the results of the linear regression and regression by means of neural networks will be compared. The comparison will not be carried out as a residuals analysis (minimum and maximum values, dispersion of residuals, etc.), but at the level of the expert view and experience of evaluator, an economist.

3 Results

3.1 Linear regression

The correlation coefficient is 0.9731, which is a statistically significant direct dependence of the export on the development over time. The determination coefficient has a value of 0.9470.

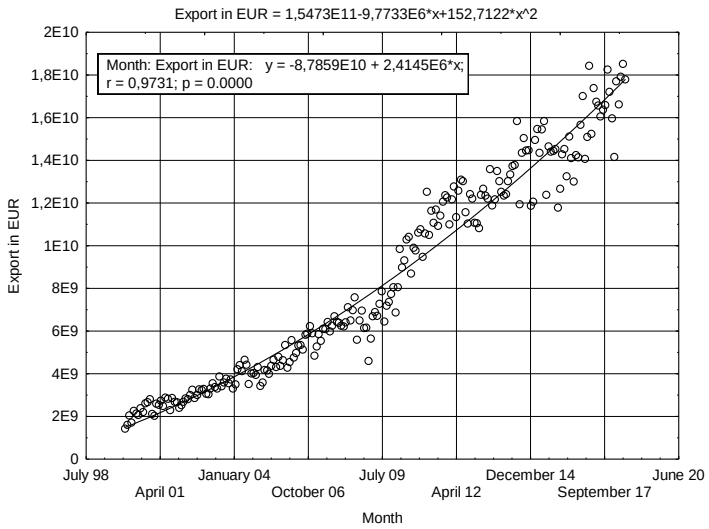
A scatter plot was designed (see Figure 2), where the individual points were fitted by the regression curve, linear in this case. The curve parameters are shown in the Figure.



Source: Own processing

Figure 2 Scatterplot showing EU export to PRC, with fitted regression curve – linear function

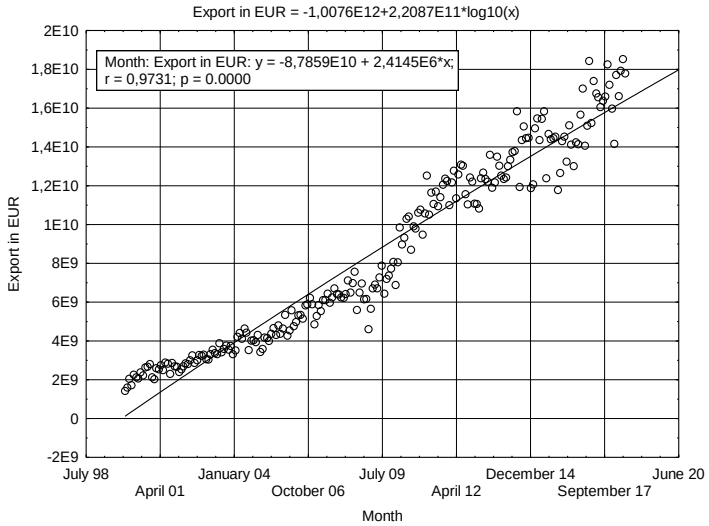
The solid line represents the regression function. At first sight, the curve captures the development of the monitored variable very well. Figure 3 shows a scatter plot with fitted polynomial function.



Source: Own processing

Figure 3 Scatter plot of EU export to PRC with fitted regression curve – polynomial function

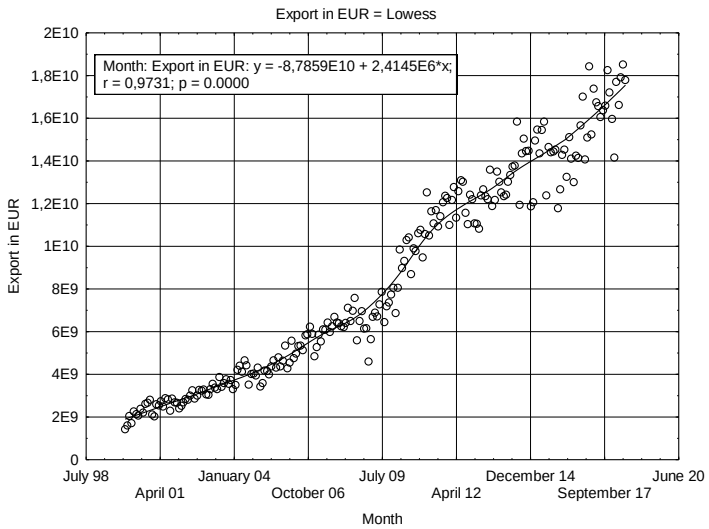
Polynomial function captures the development of the EU export to the PRC slightly better than the linear function. Figure 4 shows a scatter plot with fitted logarithmic function.



Source: Own processing

Figure 4 Scatter plot of EU export to PRC with fitted regression curve – logarithmic function

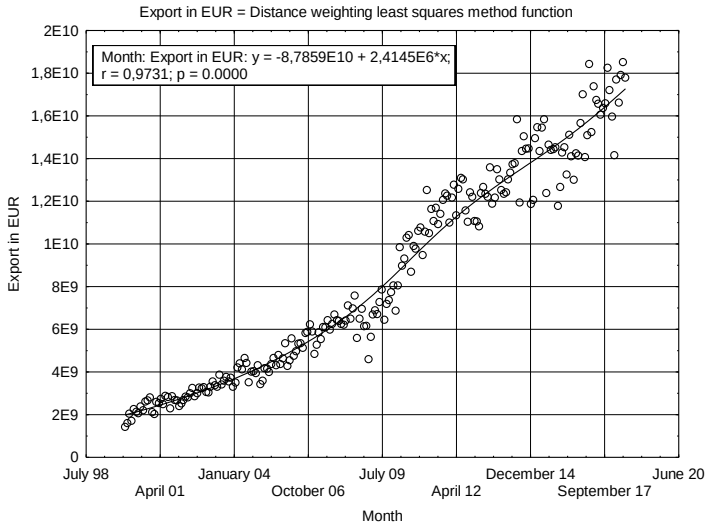
The shape of the curve and location of the individual points in the graph indicates that the logarithmic function replicates the linear function, thus predicting the development of the EU fairly well. Figure 5 represents LOWESS (locally weighted scatterplot smoothing), or LOES (locally estimated scatterplot smoothing) function.



Source: Own processing

Figure 5 Scatter plot of EU export to PRC with fitted regression curve – LOWESS

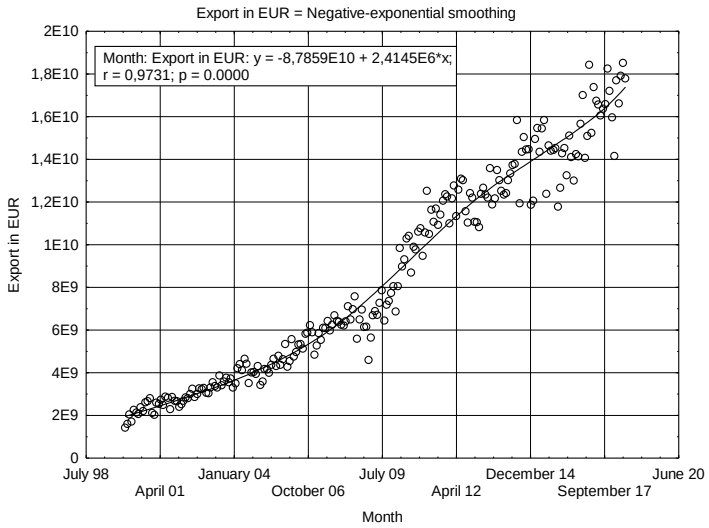
Regression for such a curve is calculated in partial intervals. The LOWESS curve equalizes the time series and follows its trend. Fitting by means of the LOWESS curve appears to be very interesting. It is able to predict the development trend of the EU export to the PRC. Figure 6 shows a scatter plot of the EU export to the PRC with fitted function obtained by means of the distance-weighting least squares method.



Source: Own processing

Figure 6 Scatter plot of EU export to PRC with fitted regression curve – distance weighting least squares method function

The curve replicates the development of the EU export to the PRC in its entire interval. However, it must be stated that in the detail, the curve is less precise than the previous LOWESS curve. Figure 7 shows fitting by means of function obtained by the negative exponential smoothing least squares method.



Source: Own processing

Figure 7 Scatter plot of EU export to PRC with fitted regression function – negative exponential smoothing least squares method

This curve also appears to be interesting and suitable for a potential prediction. As already stated, the correlation coefficient indicates statistically significant direct dependence of the target variable on the development over time. The correlation coefficient is close to the limit value of 1. It can be stated that all created regression curves equalize the time series fairly well and at a certain level of accuracy, they show interesting results. If the results were assessed only based on the optical comparing of the EU export to the PRC and the regression curve shape, considering at the same time a simple linear regression, it could be stated that the LOWESS shows even better parameters. Other suitable curves are the curves obtained by the least squares methods, in particular by negative

exponential smoothing and distance weighting. All of the three curves replicate the development of the EU export to the PRC.

3.2 Neural structures

Based on the aforementioned procedure, in total 10,000 neural structures were generated out of which 5 networks with the best parameters were retained. For their overview, see Table 2.

Table 2 Retained neural networks

	1	2	3	4	5
Network	RBF 1-26-1	RBF 1-29-1	RBF 1-29-1	RBF 1-24-1	RBF 1-25-1
Training perform.	0.988988	0.988831	0.988486	0.984297	0.983734
Testing perform.	0.985616	0.988322	0.988213	0.982806	0.987456
Validation perform.	0.986879	0.986892	0.987120	0.987108	0.987533
Training error	2.456164E+17	2.491079E+17	2.567633E+17	3.498046E+17	3.622694E+17
Testing error	4.005751E+17	3.249333E+17	3.356671E+17	4.809637E+17	3.572135E+17
Validation error	3.845149E+17	4.028760E+17	3.974787E+17	3.986220E+17	3.998826E+17
Training algorithm	RBFT	RBFT	RBFT	RBFT	RBFT
Error function	Sum.quart.	Sum.quart.	Sum.quart.	Sum.quart.	Sum.quart.
Activation of hidden layer	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian
Output activation function	Identity	Identity	Identity	Identity	Identity

Source: Own processing

All of the retained networks are the radial basis neural networks. The input layer contains one variable only – time. The neural networks in the hidden layer contain between 24 and 29 neurons. The output layer logically contains only one neuron and one output variable – the EU export to the PRC. For all networks, RBFT training algorithm was applied. Moreover, all neural structures used the identical function for the activation of the neurons in the hidden layer, namely Gaussian function. Likewise, they use the same function for the activation of the neurons in the output layer, namely the identity function (for more details, see Table 2).

Training, testing and validation performance is also interesting. In general, we are looking for a network with ideally the same performance in all data sets (here it should be noted that the data were randomly divided into the data sets). At the same time, the error should be as small as possible. The performance of the individual data sets is expressed as a correlation coefficient. The values of the individual data sets by concrete neural networks are shown in Table 3.

Table 3 Correlation coefficients of individual data sets

	Exports (Training)	Exports (Testing)	Exports (Validation)
1.RBF 1-26-1	0.988988	0.985616	0.986879
2.RBF 1-29-1	0.988831	0.988322	0.986892
3.RBF 1-29-1	0.988486	0.988213	0.987120
4.RBF 1-24-1	0.984297	0.982806	0.987108
5.RBF 1-25-1	0.983734	0.987456	0.987533

Source: Own processing

It results from the table that the performance of all retained neural structures is nearly identical. The slight differences do not affect the performance of the individual networks. The value of all training data sets correlation coefficient ranges from almost 0.984 to more than 0.988. The value of testing data sets correlation coefficient is more than 0.982 for all neural networks. The validation data set correlation coefficient for all neural networks is above 0.986. To choose the most suitable neural structure, a more detailed analysis of the results obtained must be carried out. Table 4 shows the basic statistical characteristics of the individual data sets for all neural structures.

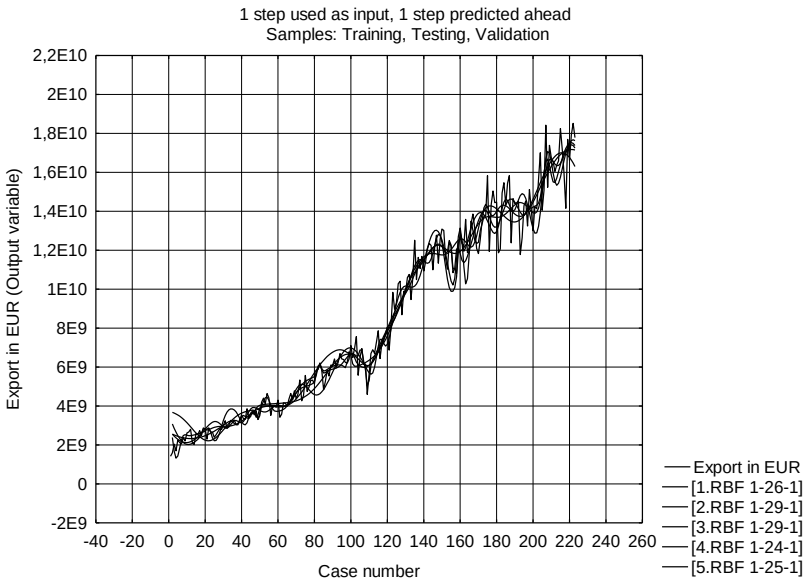
Table 4 Statistics of individual data sets by retained neural structures

Statistics	1.RBF 1-26-1	2.RBF 1-29-1	3.RBF 1-29-1	4.RBF 1-24-1	5.RBF 1-25-1
Minimal prediction (Training)	1.324366E+09	2.330010E+09	2.122872E+09	2.024698E+09	2.214571E+09
Maximal prediction (Training)	1.741536E+10	1.752462E+10	1.700726E+10	1.767183E+10	1.717502E+10
Minimal prediction (Testing)	1.431736E+09	2.339535E+09	2.271759E+09	2.141664E+09	2.264442E+09
Maximal prediction (Testing)	1.736600E+10	1.749158E+10	1.696743E+10	1.762770E+10	1.716703E+10
Minimal prediction (Validation)	2.536782E+09	2.351635E+09	2.344404E+09	2.214503E+09	2.220246E+09
Maximal prediction (Validation)	1.646363E+10	1.655168E+10	1.700041E+10	1.670868E+10	1.690947E+10
Minimal residuals (Training)	-2.920427E+09	-3.081541E+09	-2.784484E+09	-2.827718E+09	-2.955660E+09
Maximal residuals (Training)	2.472351E+09	2.274404E+09	2.300036E+09	3.070099E+09	3.311586E+09

Source: Own processing

Ideally, the individual statistics of the neural networks match horizontally in all data sets (minimum, maximum, residuals etc.). In the case of equalized time series, the differences in terms of individual variables are minimal. It is therefore not possible to identify which of the retained neural networks shows the best results.

Figure 8 shows a line graph representing the actual development of the EU export to the PRC and the development of predictions by means of individual generated and retained networks. It results from the graph that all the neural networks´ predictions are slightly different in individual intervals. However, the important fact is not the similarity of the individual networks predictions, but their similarity (or degree of conformity) with the actual development of the variable monitored. Based on the optical comparison of the individual curves trend it can be stated, that all the retained neural networks follow the gradient of the curve representing the development of the EU export to the PRC and also perceive the extremes of the curve.



Source: Own processing

Figure 8 Line graph – development of EU export to PRC predicted by neural networks compared with actual export in monitored period

4 Discussion and conclusion

The objective of the contribution was to compare the accuracy of equalizing time series by means of regression analysis and neural networks on the example of the EU export to the PRC.

Generally, each prediction is given by a certain degree of probability of its fulfilment. To predict a future development of any variable means to try to estimate its future development based on the data from the previous periods. Although we are able to include most of the factors influencing the target variable in the model, there is always a certain simplification of the reality; we thus always work with a certain degree of probability that the scenario predicted will come true.

At the same time, it must be stated that the correlation coefficient is not equal to the degree of probability that a specific phenomenon will occur. It is only a mathematical variable evaluating a relation of two or more variables generated in the past, and we try to predict the future development analogically to the development in the past. Both, in the case of the linear regression and regression by means of neural networks, the reality is significantly simplified. We work with two variables only: input (time) and output (the EU export to the PRC). We thus do not consider any other input variables that often significantly affect the EU export to the PRC (international political situation, taxation in both countries, production factors price, government export subsidies, promotion of entrepreneurship, living standards of the target country inhabitants and many others). However, it is still true that aggregated variables are easier to predict than sub-variables. There-fore, for some analyses, it is possible to use regression by means of neural networks, which show higher accuracy.

At the same time, it can be stated that due to the high simplification of the reality it is not possible to predict extraordinary situations and their impact on the EU export to the PRC (at least not in the long term). Prediction in the order of days would be ideal; however, it is not possible to obtain data for such a short prediction. The EU export to the PRC can be identified based on statistical, causal and intuitive methods. In this case, we dealt with the comparison of the statistical methods. These, however, provided only a possible framework of the monitored variable development. It is important to work with the information on a possible future development of political, economic or legal environment. If we are able to predict its development, it can later be considered in the monitored variable. Nevertheless, it is also important the evaluator – economist, who, on the basis of his or her experience and knowledge, corrects the price determined by means of statistical methods and specified based on the causal links.

Optically, in terms of the linear regression, the most suitable one appeared to be the LOWESS curve. The second best possible was the curve obtained by the negative exponential smoothing least squares method and distance-weighting least squares method. In terms of neural networks, all retained neural structures appeared to be applicable in practice, as there was no significant difference between them. The objective of the contribution has been achieved. Due to the actual trend of the EU export to the PRC, it is possible to investigate predicting future developments taking into account seasonal fluctuations.

References

CANOFARI, P., DEL PONTE, A. (2018). Chinese and European Financial Systems: Instability Drivers and Contagion Channels. *International Advances in Economic Research*, 24(4), 311-324. Doi 10.1007/s11294-018-9713-9.

CAPROTTI, F. (2015). Golden sun, green economy: market security and the US/EU-China 'solar trade war'. *Asian Geographer*, 32(2), 99-115. Doi 10.1080/10225706.2015.1057191.

CARDOSO, A., DUARTE, A. (2017). The impact of the Chinese exchange policy on foreign trade with the European Union. *Brazilian Journal of Political Economy*, 37(4), 870-893. Doi 10.1590/0101-31572017v37n04a12.

CURRAN, L., LV, P., SPIGARELLI, F. (2017). More heat than light? Renewable energy policy and EU-China solar energy relations. *International Journal of Ambient Energy*, 38(5), 471-480. Doi 10.1080/01430750.2016.1195775.

GABRIEL, J., SCHMELCHER, S. (2018). Three scenarios for EU-China relations 2025. *Futures*, 97, 26-34. Doi 10.1016/j.futures.2017.07.001.

GOETZ, L., GRETHE, H. (2010). The entry price system for fresh fruit and vegetable exports from China to the EU-Breaking a fly on the wheel? *China Economic Review*, 21(3), 377-393. Doi 10.1016/j.chieco.2010.02.001.

KARKANIS, D. (2018). EU-China Trade: Geography and Institutions from 2001 to 2015. *Journal of Economic Integration*, 33(1), 1158-1175. Doi 10.11130/jei.2018.33.1.1158.

LA DELFA, N. J., POTVIN, J. R. (2016). Predicting manual arm strength: A direct comparison between artificial neural network and multiple regression approaches. *Journal of Biomechanics*, 49(4), 602-605. Doi 10.1016/j.jbiomech.2016.01.008.

LE CAILLEC, J. M., GARELLO, R. (2003). Time series nonlinearity modeling: A Giannakis formula type approach. *Signal Processing*, 83(8), 1759-1788. Doi 10.1016/S0165-1684(03)00092-6.

MAU, K. (2017). US Policy Spillover (?) - China's Accession to the WTO and Rising Exports to the EU. *European Economic Review*, 98, 169-188. Doi 10.1016/j.euroecorev.2017.06.015.

MERDUN, H., et al. (2006). Comparison of artificial neural network and regression pedotransfer functions for pre-diction of soil water retention and saturated hydraulic conductivity. *Soil and Tillage Research*, 90(1-2), 108-116. Doi 10.1016/j.still.2005.08.011.

SPIGARELLI, F., ARTECONI, A., CURRAN, L. (2017). Europe-China cooperation and competition in the green industries. *International Journal of Ambient Energy*, 38(5), 443-443. Doi 10.1080/01430750.2017.1333712.

TAO, F., et al. (2018). Driving forces of energy embodied in China-EU manufacturing trade from 1995 to 2011. *Resources, Conservation and Recycling*, 136, 324-334. Doi 10.1016/j.resconrec.2018.04.021.

TU, J. V. (1996). Advantages and disadvantages of using artificial neural networks versus logistic regression for predicting medical outcomes. *Journal of Clinical Epidemiology*, 49(11), 1225-1231. Doi 10.1016/S0895-4356(96)00002-9.

VOITURIEZ, T., WANG, X. (2015). Real challenges behind the EU-China PV trade dispute settlement. *Climate Policy*, 15(5), 670-677. Doi 10.1080/14693062.2015.1009868.

VRBKA, J., ROWLAND, Z. (2017). Stock price development forecasting using neural networks. *SHS Web of Conferences*, 39. Doi 10.1051/shsconf/20173901032.

ZEKIĆ-SUŠAC, M., et al. (2016). Predicting company growth using logistic regression and neural networks. *Croatian Operational Research Review*, 7(2), 229-248.

SECTION 2
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FINANCE IN DIGITAL TRANSFORMATION

The reaction of the Slovak Financial Administration to transfer pricing issues

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Abstract

Purpose of the article The main purpose of this paper is to bring a new perspective on the connection of transfer pricing, its controls by the Financial Administration of the Slovak Republic and the transfer of the headquarters of Slovak companies to selected tax havens.

Methodology/methods The analysis is based on the use of secondary data from the Annual Reports of the Slovak Financial Administration and the company Bisnode (2005-2017). The paper uses graphical methods to visualize the development of the selected indicators and calculation of the ratio of corporate income tax revenues (CITR) per gross tax revenues (GTR). The last method is a simple linear regression model that detects the dependence between the number of companies with ownership link to tax haven and the number of transfer pricing controls performed.

Scientific aim The scientific aim of this contribution is to analyze the approach of the Slovak Financial Administration in the context of tax audits in the framework of transfer pricing, supplemented by an analysis of the relationship between controls on transfer pricing and the moving of Slovak companies into tax havens.

Findings Since 2015, there has been a sharp increase not only in the number of tax inspections for transfer pricing, but also in the level of findings. An increasing number of Slovak companies with the owner in midshore jurisdictions have a statistically significant impact on the number of inspections carried out under transfer pricing and the number of Slovak companies with owners in Cyprus, Luxembourg and Liechtenstein has a statistically significant impact on the share of CITR per GTR.

Conclusions The main limits include the incomplete list of tax havens which are used at the first level of ownership by Slovak companies. The outcomes of our analysis point to the statistically significant impact of the use of companies from Cyprus, Luxembourg and Liechtenstein on corporate income tax revenues, but do not specify the methods and techniques of profit shifting applied by the companies.

Keywords: corporate income tax, financial administration, Slovak Republic, tax haven, tax inspection, transfer pricing

JEL Classification: H25, H26, H70

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Introduction

Transfer pricing is an increasingly discussed topic not only in the world, but also in Slovakia, where every year the number of tax inspections grows in this area. The subject matter at an academic level is often viewed only in terms of transfer pricing, dependent and independent relations and various constraints. We have looked at the transfer pricing from the point of view of the Financial Administration of the Slovak Republic and also from the point of view of transfer pricing relation and relocation of the headquarters of Slovak companies into jurisdictions called tax havens.

Based on available data, the scientific aim of the contribution is to analyze the approach of the Slovak Re-public's financial administration in the context of tax audits of transfer pricing, supplemented by an analysis of the relation between controls on transfer pricing and the transfer of Slovak companies into tax havens. The partial aim is to point to the indicators used by the SR's Financial Administration for transfer pricing controls and the impact assessment of the transfer of the registered office of Slovak companies in selected jurisdictions to the corporate income tax revenue and gross tax revenues indicator.

The basic constraints limiting our contribution are mainly incomplete data of the Slovak Republic's Financial Administration on transfer pricing for selected years and a limited list of tax havens where Slovak companies are based according to the database of Bisnode, ltd.

1 Theoretical background

In the professional literature we encounter several ways of transferring profits within tax systems (from jurisdictions with higher tax burden to jurisdictions with lower or no tax burden). These profit-shifting techniques include the use of debt, interests, royalties, placement of intangible assets, financing of related persons, setting dividend flows and ultimately transfer pricing (Karkinsky and Riedel, 2012; Auerbach et al., 2017). However, for the sake of our further investigation, we only chose the last option.

Tax havens often associated with the transfer of profits are not only small tropical islands with low or no taxation and full offshore jurisdictions, but also countries that have a diversified economy and a normal tax system but with certain, often deliberately designed, exceptions for particular activities or types of corporate activities that can be used by multinationals to substantially lower their overall tax burden (onshore and midshore) (e.g. Weizig and Van Dijk, 2007; Valencia, 2013; Foad and Lundberg, 2017).

Transfer pricing is a technique that optimizes costs and returns between divisions and subsidiaries within a group of related entities, not only the accounting technique (Tax Justice Network, 2015). This technique allows the artificial transfer of profits from high tax jurisdictions to jurisdictions with lower tax burden (Sikka and Willmott, 2010; Ball, 2013). From another perspective, transfer pricing is a phenomenon by which affiliated legal entities in different jurisdictions determine the price at which goods or services should be sold between those two entities. This phenomenon is an indispensable and endemic part of the international trading system (Bastin, 2014). Transfer prices "are the prices for goods and services that each subsidiary and parent company accounts for in the transnational corporation" (Ďurčová, 2011; Valencia, 2013). Taxpayers are focused on reducing taxable business earnings, so they are interested in generating profits where they are most tax-friendly (Solilova and Nerudova, 2013). This advantage can be achieved by transferring profits between foreign affilites to countries with the lowest rate of income tax. High transfer rates for the sale of goods by affiliates in high tax rates are used to repatriate profits to low tax countries, thereby reducing the overall tax burden (Behrens, Peralt and Picard, 2014; Usmen, 2012).

Business consultants agree that transfer pricing is currently one of the most important tax planning topics. With regard to a rapidly regulated environment where transparency is at the forefront, taxpayers achieve a degree of certainty in managing their taxes and potential risks through so-called "Advance pricing agreements" (APA) (agreement between the tax authority and the taxpayer on appropriate transfer pricing methodology for a selected set of transactions for a specified period of time) (PWC, 2014). Using APA, there is often a double non-taxation in corporate income tax using low or zero-tax jurisdictions (one of the potential profit-shifting channels to tax havens) (Fernandez et al., 2013).

OECD, whose individual standards are transposed by the Member States, either in full or partially altered, helps in further transfer pricing regulations (Blouin et al., 2018). The OECD Transfer Pricing Risk Assessment Guide recommends setting a threshold for a transaction at which value (tax amount) it is appropriate to initiate tax control when tax control is effective. This "threshold" should be set according to the annual gross value of the transactions

under control or the total company income. Of course, recurring transactions themselves may not pose a risk, but other factors need to be taken into consideration (i.e. whether transaction prices are in accordance with the principle of an independent relationship, where transactions are directed, or jurisdictions with higher tax burdens, etc.) (OECD, 2013).

The new OECD Transfer Pricing Regulation focuses primarily on multinational companies and, in addition to modifying the documentation on global and transfer pricing, also significantly improves tax authorities' awareness, which has an impact on a better assessment of tax risks and more targeted processes in the transfer pricing audit (OECD, 2017). However, multinational companies and their tax optimization led to discussions even before that. In 2013, the OECD developed a Base Erosion and Profit Shifting (BEPS) project containing 15 action areas, reports and recommendations to tax avoidance for countries (Dharmapala, 2014). These reports were first published in a complete package in October 2015. The main focus of BEPS is on unfair practices aimed at minimizing tax liability through tax base distortions and the subsequent transfer of profits to other countries (OECD, 2013). In addition to the transfer pricing section, BEPS also provides a framework for tax challenges in the digital economy. To that end, the European Commission reflected the proposal for directives, namely Proposal for a COUNCIL DIRECTIVE laying down rules on the corporate taxation of a significant digital presence (COM / 2018/0147 final - 2018/072 (CNS)) and Proposal for a COUNCIL DIRECTIVE on the common system of taxation for digital services (COM / 2018/0148 final - 2018/073 (CNS)).

2 Methodology and data

Based on available data, the scientific aim of this paper is to analyze the approach of the Slovak Republic's Financial Administration in the context of tax audits within transfer pricing, supplemented by an analysis of the relationship between controls on transfer pricing and the transfer of Slovak companies into tax havens. The partial aim is to evaluate the indicators published by the financial administration and to assess the impact of the transfer of Slovak companies into tax havens on the indicator of corporate income tax revenues per gross tax revenues.

Graphical methods, calculation of indicators and simple linear regression model are used for the analysis of the selected issue. In the first part of the analysis using graphical techniques, which are supplemented by indicators of tax administration efficiency, we show the dependence of the number of findings by the Financial Ad-ministration of the Slovak Republic on the number of controls performed. Efficiency is measured by the proportion of the controls (findings in thousands of EUR) and the number of tax inspections carried out (findings per number of transfer pricing controls). The second part of the analysis uses also, in addition to graphical methods depicting the dependence of findings by the Financial Administration of the Slovak Republic on the number of transfer pricing controls, a simple linear regression model, which determines the dependence between the number of tax controls carried out on transfer pricing (dependent variables) and the number of Slovak companies with ownership link to tax havens (independent variable). In this part of the analysis, we have divided the jurisdictions into three categories, namely OFFSHORE, MIDSHORE and ONSHORE. The breakdown was based on two approaches. The first was the frequent distribution of tax havens to these categories in academic and professional sources (e.g. Foad and Lundberg 2017; The Economist, 2013), and the second approach was the use of first-level ownership in selected countries given the benefits that can be used. In offshore jurisdictions, the use of first-level ownership is primarily intended for the anonymity of the UBO (Ultimate Beneficial Owner), tax optimization directly using offshore jurisdictions alone, due to the existence of a withholding tax (35%) is nearly impossible. The OFFSHORE jurisdictions include: Bahamas, Belize, Bermuda, British Virgin Islands, Gibraltar, Guernsey (United Kingdom), Jersey (United Kingdom), Cayman Islands, the Marshall Islands, the Netherland Antilles, Panama, Man Island and Seychelles. Other jurisdictions we have data of from Bisnode, ltd. are further included in the onshore category, sometimes using midshore (professional and academic resources). We have divided them on the basis of their primary use, in the case of taxes, we have used the MIDSHORE CATEGORY (Hong Kong, Cyprus, Malta, United Arab Emirates, United States of America); in the case of the primary asset management concept and the flexible arrangement of ownership relationships, we used ONSHORE CATEGORY (Liechtenstein, Latvia, Luxembourg, Monaco and the Netherlands).

In the last part we use the calculation of corporate income tax revenues (CITR) per gross tax revenues (GTR). The simple linear regression used in the last part of the analysis examines the dependence between the calculated indicator (dependent variable) and the number of Slovak companies in selected jurisdictions - Cyprus, the Netherlands, Luxembourg, Liechtenstein, Malta, United Arab Emirates and the USA (independent variable x). All regressions are evaluated at 5% significance level. We have chosen the tested jurisdictions given the assumption

that it is possible to use methods and techniques of profit-shifting (mainly based on double taxation treaties, EU Directives and tax information exchange agreements) through first-level ownership.

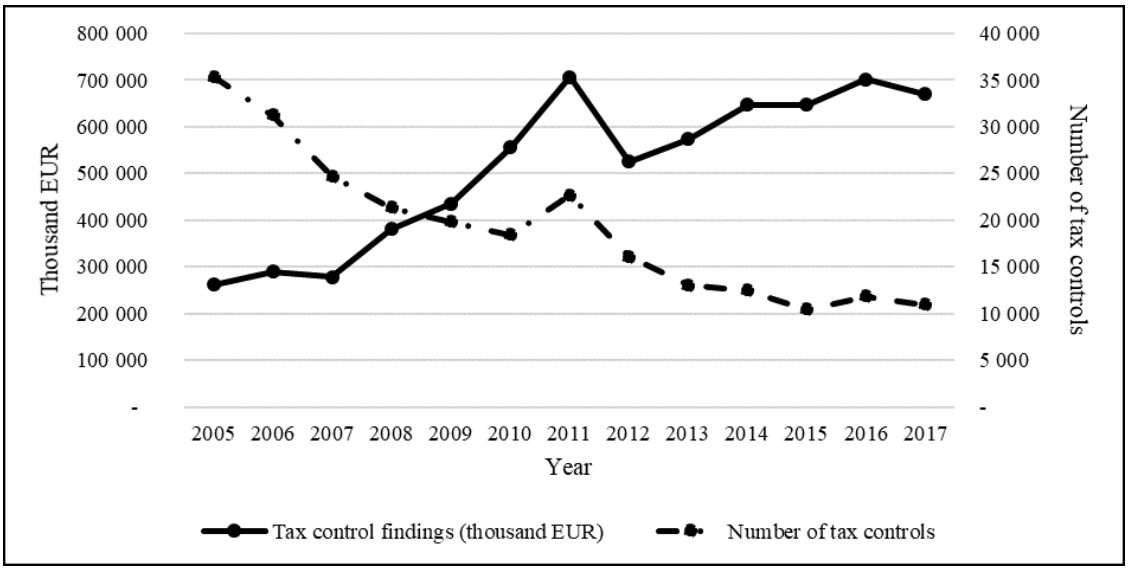
The secondary data used for the analysis are drawn from the annual reports of the Slovak Republic's Financial Administration for the period 2005 to 2017. We obtained the information on the number of companies that moved their registered office to another jurisdiction from Bisnode, ltd. also for the period 2005-2017.

3 Results

The research results were divided into three parts, based on which we examined the matter in different ways. First part is an analysis of the Financial Administration of the Slovak Republic approach and effectivity. This was executed based on the indicators regularly published by the Financial Administration. Second part is focused on transfer pricing, related indicators and examination of the relationship between transfer pricing controls and the number of Slovak companies that transferred their registered offices to selected jurisdictions during the period considered. In such examination we are dividing the jurisdictions not only to onshore and offshore but for the purposes of anticipated statistical significance we are adding the third group, midshore. Third part of the analysis shows the indicator calculated by us, a share of corporate income tax revenues (CITR) per gross tax revenues (GTR). This part also covers the relation between development of number of companies in selected jurisdictions (Cyprus, Netherlands, Luxembourg, Liechtenstein, Malta, United Arab Emirates and USA) and development of CITR/GTR indicator. The whole analysis is based on the data collected between 2005 and 2017.

3.1 Development of tax control indicators

Tax control is considered to be a large-scale activity which serves to examine or verify the tax base or other matters decisive for correct tax determination or chargeability. In general, the tax control serves as an important prevention tool and as such, together with other inputs, promotes voluntary tax compliance by taxable persons. Based on this we examined the results of all tax controls carried out between 2005 and 2017 (Figure 1).



Source: the authors based on annual reports of Slovak Financial Administration, 2005-2017

Figure 1 Development of number of carried out tax controls and findings

The number of total tax controls (both direct and indirect taxes) carried out significantly decreased since 2005 and showed a downward trend from 35,333 to the current 10,956 controls per year while in the last three years the average number of controls carried out was eleven thousand. The effectivity of these controls, measured by the number of findings per control, is on the other hand increasing every year. This is shown in the source table (Table 1), where in the beginning of the examined period there were 7,400 EUR of findings per control while in 2010 it was around 30,200 EUR and currently, the number is almost the double, there are 61,000 EUR of findings per one control.

Table 1 Selected indicators of the Financial Administration of the Slovak Republic

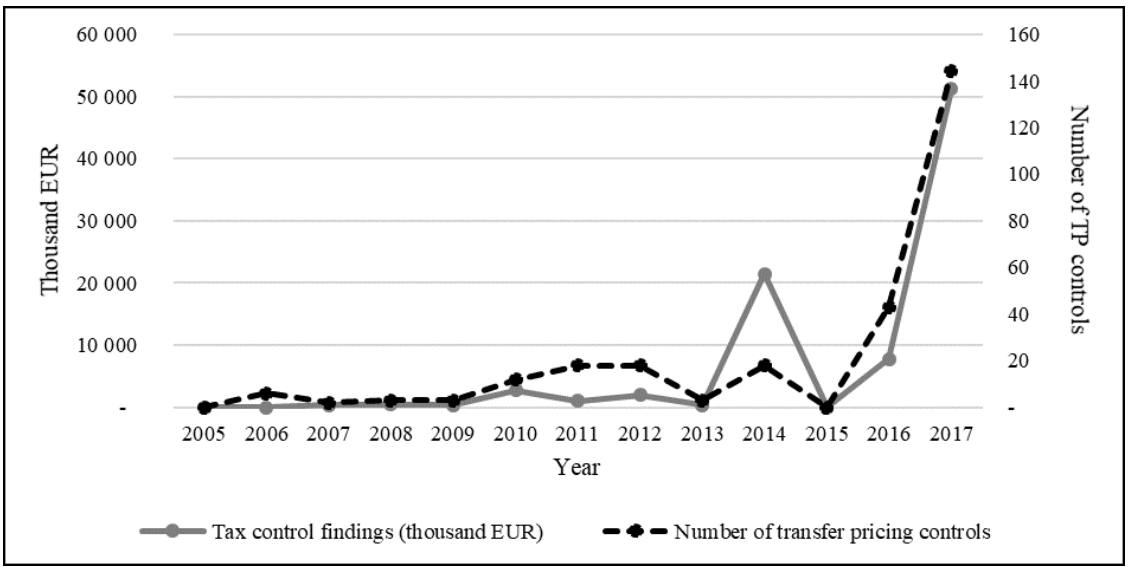
	2005	2006	2007	2008	2009	2010	2011
Number of tax controls	35,333	31,243	24,711	21,357	19,820	18,400	22,651
Tax control findings (in thousand EUR)	261,866	289,523	278,814	380,868	435,549	556,278	707,097
Average finding per control (in thousand EUR)	7.4	9.3	11.3	17.8	22.0	30.2	31.2
	2012	2013	2014	2015	2016	2017	
Number of tax controls	16,053	13,059	12,488	10,417	11,823	10,965	
Tax control findings (in thousand EUR)	525,096	573,215	646,863	647,293	701,368	670,056	
Average finding per control (in thousand EUR)	32.7	43.9	51.8	62.1	59.3	61.1	

Source: the authors based on annual reports of Slovak Financial Administration, 2005-2017

The reason for positive results of tax controls is a fact that during the preparation stage the Financial Administration of the Slovak Republic is focusing on collecting and evaluating high quality and relevant data which increases the effectivity of controls. That means that the Financial Administration of the Slovak Republic is selecting the subjects for tax control more precisely and tax inspectors are better prepared for tax controls. We could also consider higher number of incorrectly managed documentation by specific subjects which is increasing. There are higher demands on documentation management and software and there are frequent legislative changes in place. There are also findings of individual controls with high value that therefore increase the financial average finding of all controls.

3.2 Tax controls focused on transfer pricing

Since the Financial Administration of the Slovak Republic started to focus on the international taxation and transfer pricing and initiated an intensive tax control in this area by allocating specialized inspectors, we observe the change in the development of these controls' findings. On Figure 2 we can see the control activities of the Financial Administration of the Slovak Republic, more precisely of the transfer pricing tax controls and tax control findings.



Source: the authors based on annual reports of Slovak Financial Administration, 2005 – 2017

Figure 2 Development of controls and findings within the scope of transfer pricing

In the figure, we can see that since 2013 the number of transfer pricing controls show an increasing tendency (except for 2015 when the data was not published by Financial Administration). It can be assumed that with the introduction of action plan BEPS in October 2015, the number of controls increased, which influenced the higher number of tax controls in 2016 as is shown on the figure. In 2017 the number of controls reached the highest point. In that year tax inspectors carried out not only transfer pricing controls but also network controls, multilateral controls and controls focusing on applying double tax treaties. Together 144 such controls were carried out with the finding of 51,152 EUR. This action of the Financial Administration of the Slovak Republic could be a result of individual changes in the Income Tax Act together with BEPS action plan implementation.

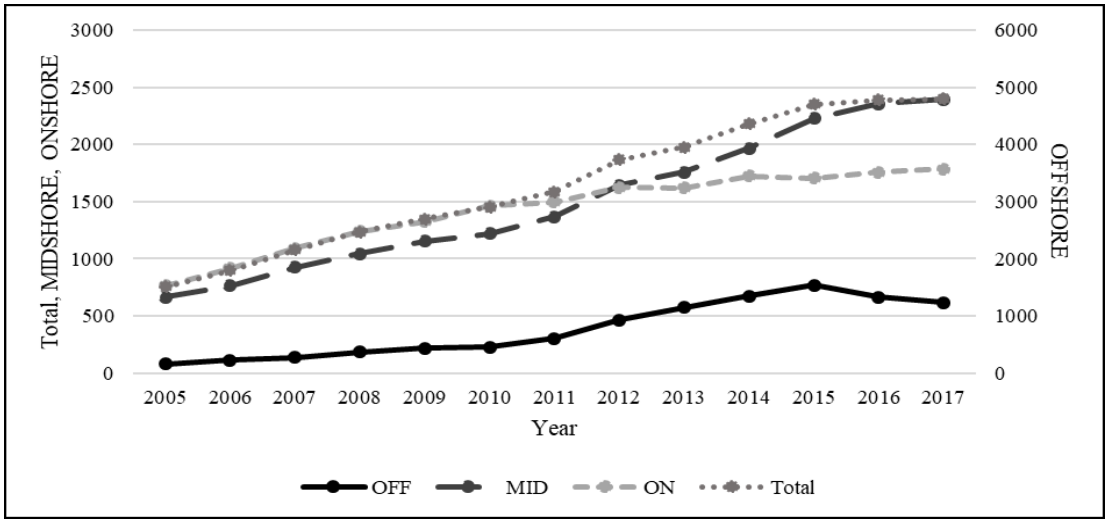
In 2015 the Financial Administration of the Slovak Republic also published a useful checklist that should help tax administrators while carrying out controls focused on transfer pricing (Table 2).

Table 2 Risk transactions checklist

Indicator	Brief description
Transactions with related parties in preferential tax regime jurisdictions	The risk of wrong pricing followed by profit-shifting to jurisdictions with preferential tax regime.
Transfers of intangible assets to related parties	Such transactions are difficult to evaluate, especially in cases related to a specific intangible asset with no data to compare with.
Business restructuring	These aspects were specifically described in Chapter IX on the Transfer Pricing Aspects of Business Restructurings from July 2010.
Specific payment types	Interests, premium insurance and royalties often cause transfer pricing risk; the payments do not reflect added value of dependent entity.
Long-term loss-making	Long-term loss-making where there is no attempt made to change business operations or financing. Sustained losses may be evidence that the reported results do not reflect the true value of the business.
Unfavourable financial results	Similarly results that are not consistent with industry norms or with the functions carried on by the taxpayer in the country concerned may be an evidence that related party transactions have not been correctly priced.
Effective tax rates	If there are significant variations between the effective tax rate reported at group level and the nominal rates to which it is subject can be the result of transfer pricing that allocates too much profit to jurisdictions with preferential tax regime.
Incorrect or non-existent documentation	If the taxpayer cannot provide the transfer prices setting and the methods used to determine them are inadequately recorded, it is a sign of transfer pricing risk.
Excessive Debt	If the debt of the taxpayer is in excess of the amount that an entity could borrow if it were a free-standing entity, or interest rates that appear to be higher than market rates.

Source: the authors based on Financial Administration data, 2015

Transfer pricing itself, as was mentioned in the theoretical section, is a technique used for tax planning and enables artificial profit shifting out of jurisdictions with a high tax burden to jurisdictions with a lower or no tax burden. Therefore, we investigated the relationship between the number of transfer pricing controls and the number of Slovak companies that transferred their registered offices to a tax haven. We examined this relation-ship in terms of the whole analysed period from 2005 to 2017, not only in respect of the number of companies, but also in respect of individual jurisdiction categories – offshore, midshore and onshore. The below figure (Figure 3) shows the development in the number of companies according to the Bisnode database. Whether it is an ONSHORE or MIDSHORE jurisdiction we can see a continuous increase in the number of companies that transferred their registered office to tax havens. The only category with decreasing tendency is OFFSHORE and this only occurs since 2015. We could assume that one of the reasons for a decrease in the offshore category is a negative perception of an offshore company as an owner at the first ownership level.

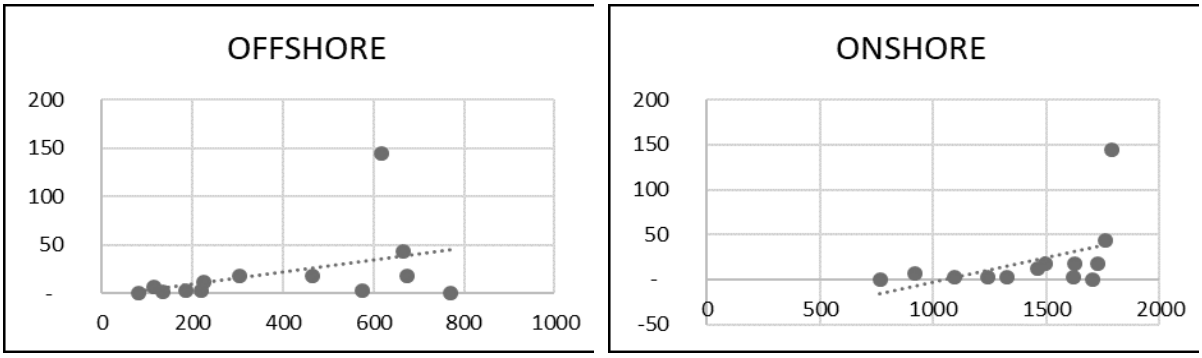


Source: the authors based on data from Bisnode database, 2018

Figure 3 Development of the number of Slovak companies in tax havens

Looking at the development in the number of tax controls and the number of companies that transferred their registered offices to a tax haven we can assume a positive relationship, however this is not supported by the statistical survey. We verified the relationship through simple linear regression model. As variables we selected the number of transfer pricing controls (dependent variable y) and the total number of companies that transferred their registered office to tax havens (independent variable x). Thereafter we changed the independent variable with the number of companies in ONSHORE, MIDSHORE and OFFSHORE jurisdictions. We evaluated the relationship based on p-value and 5% significance level.

The results of the first version of the regression model which includes the number of transfer pricing controls and the total number of companies (total) that transferred their registered office to a tax haven were statistically insignificant because the p-value exceeded the significance level 0.05 (p-value = 0.067), therefore did not confirm the statistically significant dependence. However, the result indicated that the statistical significance might be confirmed by following tests with the division of jurisdictions into OFFSHORE, MIDSHORE and ONSHORE. The following analysis showed that the relationship between the number of companies that transferred their registered office to ONSHORE and OFFSHORE jurisdictions and number of transfer pricing controls examined at 5% significance level (p-value (ONSHORE) = 0.11; p-value (OFFSHORE) = 0.18) was not confirmed, which is also the results of the figures



Source: the authors

Figure 4 Relationship between the number of transfer pricing controls and the number of companies in OFFSHORE and ONSHORE jurisdictions

Statistical significance dependence was only confirmed regarding the relationship between the number of transfer pricing controls and the number of companies that transferred their registered offices to MIDSHORE jurisdictions.

This relationship highly confirms our assumption that companies in midshore category are used in the process of tax optimization, hence the Financial Administration of the Slovak Republic carries out more controls. Such a statement is to a large extent a simplification, considering the list of tax havens we are working with. However, we could see a tendency of a kind.

Table 3 Results of simple linear regression of MIDSHORE jurisdictions

	Regression Statistics				
Multiple R	0.582763005				
R Square	0.33961272				
Adjusted R Square	0.279577513				
Standard Error	33.01905				
Observation	13				
	df	SS	MS	F	Significance F
Regression	1	6167.4715	6167.4715	5.6569	0.0366
Residual	11	11992.8362	1090:2578		
Total	12	18160.3077			

Source: the authors

3.3 Relationship between the number of companies in selected jurisdictions and corporate income tax revenues

In the last section we examined an indicator measuring collection of corporate income tax revenues, a share of corporate income tax revenues (CITR) per gross tax revenues (GTR) and its correlation with the changing number of Slovak companies that transferred their registered offices to selected jurisdictions (Cyprus, Nether-lands, Luxembourg, Liechtenstein, Malta, United Arab Emirates and USA). These jurisdictions, as mentioned earlier, could be used for tax optimization on the first-ownership level. We based our indicator calculations on data published by the Financial Administration of the Slovak Republic in their annual reports. The increase of findings and therefore also effectivity of tax controls is reflected in the growth of gross tax revenues. On the other hand, the development of corporate income tax rate (CITR) is not that clear because it is influenced by aggressive tax planning of companies (not only the large ones) and specific business conditions in the Slovak Republic (high tax burden, discriminatory income tax, etc.). The development is shown in Table 4.

Table 4 Development of selected indicators

	2005	2006	2007	2008	2009	2010	2011
Corporate income tax R.(in thousand EUR)	1,417	1,594	1,769	2,156	2,167	1,286	1,646
Gross tax revenue (in thousand EUR)	5,688	5,675	5,985	6,564	6,342	5,286	5,852
Indicator (CITR/GTR) (in %)	24.91%	28.09%	29.56%	32.85%	34.17%	24.33%	28.13%
	2012	2013	2014	2015	2016	2017	
Corporate income tax R.(in thousand EUR)	1,759	2,028	1,948	2,641	3,222	2,637	
Gross tax revenue (in thousand EUR)	5,536	6,282	6,571	8,079	8,816	8,820	
Indicator (CITR/GTR) (in %)	31.77%	32.28%	29.65%	32.69%	36.55%	29.90%	

Source: the authors based the data from annual reports of the Slovak Financial Administration, 2005-2017

Calculated indicator is at a level of 24.33% in 2010, when Slovak entrepreneurs experienced the financial crisis at its fullest, to a level of 36.55% in 2016. This could have been influenced also by frequent changes of corporate income tax rates over the years (19%, 23%, 22% and 21%) and other changes in selected provisions of Income Tax Act.

Provided that tax optimization is taking place, the continuous increase in the number of Slovak companies in tax havens should have an influence on investigated indicators, therefore CITR/GTR (hypothesis). Table 5 contains the results of regression analysis according to which only several jurisdictions showed statistical significance.

Table 5 Results of simple linear regression of selected jurisdictions

ONSHORE jurisdictions	Netherlands	0.12 (2.9182)
	Luxembourg	0.05 (4.6373)
	Liechtenstein	0.03 (6.5601)
MIDSHORE jurisdictions	Cyprus	0.05 (4.738)
	Malta	0.15 (2.4558)
	United Arab Emirates	0.19 (1.9036)
	United States of America	0.09 (3.287)

Note: first number represents p-value, number in braces represents t-statistics

Source: the authors

4 Discussion

As mentioned in the theoretical part of this article, transfer pricing is one of the channels for profit-shifting to jurisdictions with low or no taxation. Our results are consistent with Blouin et al. (2018), claiming that OECD and standard implementation into national legislations play an important role in the area of transfer pricing. Ob-served annual increase of Slovak companies linked to tax havens could not be in general considered as a positive development, especially if we take into consideration that tax havens are not only linked to tax optimization but mostly with the anonymity of the UBOs, which enables them to perform speculative businesses.

In comparison, in the Czech Republic there has been a decrease in this statistic since 2015 (Bisnode, 2018). On the other hand, there are opinions saying that tax optimization helps the business, especially when it comes to Foreign Direct Investment (FDI). To our best knowledge, there are no similar studies in Slovakia or there are no studies estimating the potential tax gap in corporate income tax revenues in regard to tax havens. Results achieved for individual jurisdictions are in accordance with expectations mainly because Cyprus belongs to a relatively simple and affordable option to use methods and techniques of profit shifting to another tax haven (for example to offshore jurisdictions). The relationship was also confirmed in regards to states used for foreign holding structural development where apart from tax optimization benefits such as asset management, asset protection and flexible arrangements of ownership structure exist.

On the contrary, statistical relationships were not confirmed for Netherlands, Malta and United Arab Emirates (it was confirmed for USA at 10% significance level). While Malta and United Arab Emirates are used by Slovak companies relatively rarely (by the end of 2018 only 109 Slovak companies had direct equity link with Malta and 174 with United Arab Emirates), Netherlands together with Cyprus belong to the most used jurisdictions (in 2018, Cyprus had 1099 and Netherlands 1154 links with Slovak companies). To put it very simply, based on achieved results we could say that Cyprus is used mostly for tax optimization, while Netherlands at first-level of ownership is mostly used regarding to asset protection and asset management, positive image and other (e.g. large network of double tax treaties). Based on our outputs we could speak about specific tendencies. The research was limited not only in respect to a relatively short list of tax havens but also the fact that we only had access to first-level of ownership. Revised international structures often consist of multiple levels and models of transfer – multiple uses and combinations of methods and techniques of taxable profit-shifting that can be performed in accordance with the tax system (e.g. Slovakia implemented thin-capitalization rules only from 2015). In future, research in this area should not focus solely on confirming profit-shifting out of the certain jurisdictions but also on implementation and a combination of individual channels of taxable profit-shifting based on individual tax systems set up. These analyses should also assist the decision-making process when it comes to tax system adjustment and reducing the artificial profit-shifting to tax havens. The Financial Administration of the Slovak Republic works with indicators, through which risk transactions of transfer pricing can be identified, can be considered positive. Several foreign academic researches and expert analyses cover the topic of individual indicators; therefore we can clearly consider their use as beneficial for tax inspection. As the examples of the previous studies on selected indicators we can mention ROA – Return on Assets (Potin et al., 2016), BTD - Book-Tax Differences (Frank et al., 2009; Ferreira et al., 2012) and different approaches to ETR, like Rate_GaapETR, Rate_CashETR or Rate_DVA (Dyreng et al., 2008; Hanlon and Heitzman, 2010; Da Silva and Martinez, 2015).

Conclusion

The total number of tax audits carried out by the Slovak Financial Administration has been gradually de-creasing since 2005, on the other hand a higher level of these inspections is recorded annually, and tax inspections show higher efficiency. On the other hand, from 2015, when the BEPS project was adopted, there has been a sharp increase in tax audits on transfer pricing and a similarly rapid increase in the findings of these controls. While the number of Slovak companies in the categories OFFSHORE (p-value 0.18) and ONSHORE (p-value 0.11) respectively TOTAL for all jurisdictions (p-value 0.067) does not have a statistically significant impact on the number of controls carried out in the transfer pricing field, in the MIDSHORE category, this dependency was evaluated as statistically significant (p-value 0.03). As part of the analytical work of the Slovak Financial Re-port, 9 indicators were developed and published, which assess the risk transactions in the transfer pricing. This practical checklist is one of the tools for tax administrators.

In the final part of the paper, it was statistically confirmed the statistical dependence between the number of Slovak companies with parent companies from Cyprus (p-value 0.05), Luxembourg (p-value 0.05) and Liechtenstein (p-value 0.03) and the ratio of corporate income tax revenues per gross tax revenues. Our analysis shows the increased attention of the Slovak Republic's Financial Administration to transfer pricing and the im-pact of the use of selected tax havens on selecting corporate income tax revenues.

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References

AUERBACH, A. J., DEVEREUX, M. P., KEEN, M., VELLA, J. (2017). International Tax Planning under the Destination-Based Cash Flow Tax. *National Tax Journal*, 70(4), 783-802. Doi 10.17310/ntj.2017.4.04.

BALL, J. (2013). *Marks & Spencer under fire over online tax arrangements*. The Guardian, London. Retrieved from http://www.theguardian.com/business/2013/may/19/marks-spencer-tax-arrangements-europe

BASTIN, L. (2014). Transfer Pricing and the WTO. *Journal of World Trade*, 48(1), 59-80

BEHRENS, K., PERALT, S., PICARD, P. M. (2014). Transfer Pricing Rules, OECD Guidelines and Market Distortions. *Journal of Public Economic Theory*, 16(4), 650-680. Doi 10.1111/jpet.12075

BISNODE. (2018). *Daňové raje prišli o desiatky slovenských firiem*. Retrived from https://www.bisnode.sk/o-bisnode/o-nas/novinky/danove-raje-prisli-o-desiatky-slovenskych-fririem/

BLOUIN, J. L., ROBINSON, L. A., SEIDMAN, J. K. (2018). Conflicting Transfer Pricing Incentives and the Role of Coordination. *Contemporary Accounting Research*, 35(1), 87-116. Doi 10.1111/1911-3846.12375

DHARMAPALA, D. (2014). What Do We Know about Base Erosion and Profit Shifting? A Review of the Empirical Literature. *Fiscal Studies*, 35(4), 421-448. Doi 10.1111/j.1475-5890.2014.12037.x

DA SILVA, R., MARTINEZ, A. L. (2017). Restrição Financeira e Agressividade Fiscal nas Empresas Brasileiras de Capital Aberto. *Anais do Congresso Anpcont, Belo Horizonte*, MG, Brasil, 11

DYRENG, S. D., HANLON, M., MAYDEW, E. L. (2008). Long-run Corporate Tax Avoidance. *The Accounting Review*, 83(1), 61-82. Doi 10.2308/accr.2008.83.1.61

ĎURČOVÁ, J. (2011). *Medzinárodné formy podnikania*. [International forms of businesses]. Košice: Elfa. 150 p. ISBN 978-80-8086-189-6.

EUROPEAN COMMISSION. (2018). *Proposal for a COUNCIL DIRECTIVE laying down rules relating to the corporate taxation of a significant digital presence (COM/2018/0147 final - 2018/072 (CNS))*. Brusel. Retrieved from https://eur-lex.europa.eu/legal-content/SK/TXT/?uri=CELEX%3A52018PC0147.

EUROPEAN COMMISSION. (2018). *Proposal for a COUNCIL DIRECTIVE on the common system of a digital services tax on revenues resulting from the provision of certain digital services (COM/2018/0148 final - 2018/073 (CNS))*. Brusel. Retrieved from https://eur-lex.europa.eu/legal-content/SK/ALL/?uri=CELEX%3A52018PC0148

FERNANDEZ, R., McGAURAN, K., FREDERIK, J. (2013). Avoiding tax in times of austerity. Retrieved from http://www.eurodad.org/files/pdf/523c4e96e92c0.pdf

FERREIRA, F. R., MARTINEZ, A. L., COSTA, F. M., PASSAMANI, R. R. (2012). Book-tax differences and earnings management: evidence in the Brazilian equity market. *Revista de Administração de Empresas*, 52(5), 488-501. Doi 10.1590/S0034-75902012000500002

FINANCIAL ADMINISTRATION OF SLOVAK REPUBLIC. (2018). *Výročná správa o činnosti finančnej správy za rok 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016 a 2017*. Retrieved from https://www.financnasprava.sk/sk/financna-sprava/vyrocne-spravy

FOAD, H., LUNDBERG, C. (2017). The determinants od portfolio investment in offshore financial centers. *International Review of Financial Analysis*, 54(C), 76-86, Doi 10.1016/j.irfa.2017.08.003.

FRANK, M. M., LYNCH, J. L., REGO, S. O. (2009). Tax reporting aggressiveness and its relation to aggressive financial reporting. *The accounting review*, 84(2), 467-696. Doi 10.2308/accr.2009.84.2.467

HANLON, M., HEITZMAN, S. (2010). A review of tax research. *Journal of Accounting and Economics*, 50(2-3), 127-178. Doi 10.1016/j.jacceco.2010.09.002

KARKINSKY, T., RIEDEL, N. (2012). Corporate taxation and the choice of patent location within multinational firms. *Journal of International Economics*, 88(1), 176-185. Doi 10.1016/j.jinteco.2012.04.002

OECD. (2013). *Action Plan on Base Erosion and Profit Shifting*. Retrieved from http://www.oecd.org/ctp/BEPSActionPlan.pdf

OECD. (2013). *Draft Handbook on Transfer Pricing Risk Asse*ssment. Retrieved from http://www.oecd.org/tax/transfer-pricing/Draft-Handbook-TP-Risk-Assessment-ENG.pdf

OECD. (2018). *Annual Report on the OECD Guidelines for Multinational Enterprises 2017*. Retrieved from http://www.oecd.org/investment/mne/annualreportsontheguidelines.htm

POTIN, S., SILVA, V. C., REINA, D., NETO, A. S. (2016). Analise da Relacao de Dependencia entre Proxies de Governanca Corporativa, Planejamento Tributario e Retorno sobre Ativos das Empresas da BM&FBOVESPA. *Revista Organizações em Contexto*, 12(23), 455–478. Doi 10.15603/1982-8756/roc.v12n23p455-478

PWC. (2014). *Transfer pricing: Advance pricing agreements*. Retrieved from http://www.pwc.com/gx/en/tax/transfer-pricing/advance-pricing-agreements.jhtml

SIKKA, P., WILLMOTT, H. (2010). The dark side of transfer pricing: Its role in tax avoidance and wealth retentiveness. *Critical Perspectives on Accounting*, 21(4), 342-356. Doi 10.1016/j.cpa.2010.02.004

SOLILOVA, V., NERUDOVA, D. (2013). Transfer Pricing: General Model for Tax Planning. *Ekonomický časopis*, 61(6), 597-617

TAX JUSTICE NETWORK. (2015). *Transfer pricing*. Retrieved from http://www.taxjustice.net/topics/corporate-tax/transfer-pricing/

USMEN, N. (2012). Transfer Prices: A Financial Perspective. *Journal of International Financial Management & Accounting*, (23)1, 1-22. Doi 10.1111/j.1467-646X.2011.01052.x

VALENCIA, M. (2013). *Storm survivors – Special report*. The Economist. Retrieved from http://www.economist.com/news/special-report/21571549-offshore-financial-centres-have-taken-battering-recently-they-have-shown-remarkable

WEIZIG, F., VAN DIJK, M. (2007). *The global problem of tax havens: the case of the Netherlands. SOMO – Centre for Research of Multinational Corporation*. Retrieved from https://www.somo.nl/the-global-problem-of-tax-havens-the-case-of-the-netherlands/

Key Performance Indicators and the Balanced Scorecard Approach in Small and Medium-Sized Enterprises: A Literature Review

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Abstract

Purpose of the article The aim of this article is to identify possible approaches for define key performance indicators and possibilities of use balanced scorecard to this extend in small and medium-sized enterprises (SMEs).

Methodology/methods Comparison of the views of authors with the performance measurement in companies using key performance indicators, balanced scorecard and their combination with other approaches. This literature review is intended to find gaps of the studies in this area, which can lead to future research. Secondary research is used publishers such as Elsevier, Emerald, Springer and other. This literature review is actual for present year, because the level of knowledge in this area will change and expand in the future. For this reason, the main focus is on time period between 2014–2019.

Scientific aim Define performance measurement approaches based on key performance indicators and balanced scorecard and identifying knowledge gaps in this area.

Findings The results show that key performance indicators are suitable for measuring performance in companies and they are very often used with combination of fuzzy methods or Enterprise Analysis Model. But one of the most common ways is to implement key performance indicators (KPIs) depending on balanced scorecard (BSC). The gap in knowledge has been identified in the implementation of these procedures in SMEs, mainly in non-productive enterprises.

Conclusions These approaches are very suitable for measuring company performance and have sufficient evidence ability. The limitation lies in the fact that these methods requires profound knowledge of this issue and implementation is long and demanding. SMEs often lacking the necessary finances or knowledge of how implement this approach. Because of this reason, the founded gap is unforgettable problem, and it is necessary that future research be focused on this topic.

Keywords: key performance indicators, balanced scorecard, small and medium sized enterprises, performance measurement, company performance

JEL Classification: M15, M21

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Introduction

In today's fast-paced time, the economy is struggling with many changes. The turbulent environment requires increasingly diversified products and increased quality requirements, faster production processes, innovative thinking and new technologies. The basic building block and the primary concern of every business is profit and a satisfied customer. Businesses must respond quickly to changes in the economic environment while maintaining their level and competitive advantage, with the most efficient use of all resources at the lowest possible costs. Now at this point it is necessary to use the area of performance management, which deals with control of company's key processes. Nowadays, every business knows that they need to plan, manage, and continually improve their performance.

Key performance indicators as a part of performance management are one of the most up-to-date and most discussed business management issues. What key indicators are, how they are defined and developed, and a general framework for their implementation, is described, for example, by David Parmenter in his "Key performance indicators" (Parmenter, 2015). However, their applications and use still have many gaps. Most of the studies focused on this topic are dedicated to large, medium-sized and small manufacturing companies in the automotive, energy or healthcare sectors. However, medium and small non-manufacturing companies are almost forgotten. At the same time, small and medium-sized enterprises are a very important part of the whole economy, especially because they can respond more flexibly to changes in the economy because of capital limitations because they are not limited by large investment property. Their survive is also dependent on higher innovation creativity, more room for individual initiative and less restrictive organizational conditions. Managers of these companies are more intimate and more involved in innovation (Křivková, 2011).

This article is focused on level of knowledge in application key performance indicators, balanced scorecard and other methods belong to performance management to small and medium-sized enterprises and finding gap in this area.

The outputs of this article will be used as a literary research for dissertation work, which will be focused to design a comprehensive system of key performance indicators based by the balanced scorecard to testify for the fulfilment of strategic goals in the company. The dissertation will be aimed on the automotive industry, namely car dealers, not manufacturing companies, but primarily on the service companies.

1 Methodology

The subsequent chapter describes the research process of an evidence-based systematic review strategy. This research was backed by two books that are related to the subject of key performance indicators and the Balanced Scorecard approach. First book is "Key performance indicators: Developing, Implementing and Using Winning KPIs" from David Parmenter (2015) and second book is "Balanced Scorecard v praxi" from Horváth & Partners (2002). These books provide a general framework that extends and deepens the knowledge of the examined topic.

The research was limited to articles from key peer-reviewed journals that publish most of the research related to economy and papers from conferences, which were published in proceedings. The journals and proceedings included in the search are: Future Computing and Informatics Journal, Environment Systems and Decisions, Journal of Cleaner Production, Management Science Letters, Economics & Sociology, Applied Mathematical Modelling, Evaluation and Program Planning, Procedia Manufacturing, Procedia – Social and Behvioral Sciences, Procedia Economics and Finance, and Procedia CIRP.

The search was restricted to the period from the beginning of 2014 through the presence of 2019. Research in the field of key performance indicators and the Balanced Scorecard approach was very rich and discussions and researches are still rising. Each author grasps the subject matter in a different way, so there is a grat variety of views. They use different statistical measurements, mathematical methods and techniques.

The search was performed in the database Proquest Central, which provides information for more than 160 disciplines including business and economics or science and technology, in the database Business Source Complete (EBSCO), which provides full-text periodicals, reviewed periodicals, news and conference proceedings and much more, and in the citation database Web of Science, which includes both monitoring of citations of scientific papers, both regularly updated bibliographic information.

The search was performed combining the following keywords either in the title or in the abstract: ("key performance indicators") OR ("performance indicators") OR ("performance measurement") OR ("company

performance") AND ("small and medium-sized enterprises") OR ("SMEs") OR ("small and medium-sized businesses") AND ("balanced scorecard"). The relevance of the articles was ensured by reading all abstract and checking for a discussion related to the goals of future research.

Finally, 17 articles were chosen which seemed to be most relevant for the researched issue and future use in the upcoming research.

2 Balanced Scorecard

Kaplan and Norton presented the Balanced Scorecard as a model that provides executives with a comprehensive framework that can translate company's vision and strategy into a coherent and linked set of performance measures (Kaplan & Norton, 1996 quote by Ivanov, Avasilcăi, 2014).

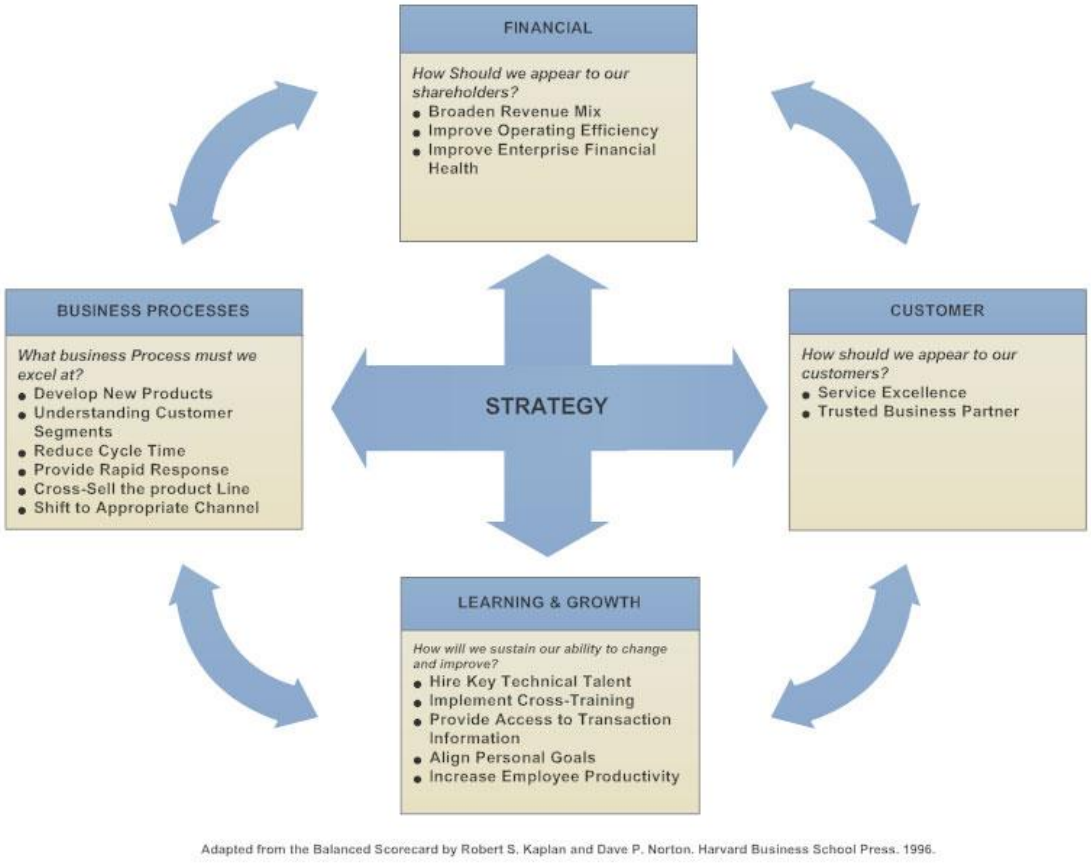
2.1 Theoretical framework

Shafiee at al say that the strongest point of BSC is its ability to illustrate the cause and effect relations between strategies and processes through the BSC's perspective (Shafiee, Lotfi, Saleh, 2014). It's true, because the Balanced Scorecard have four perspectives, which map a company from all angles and provide a comprehensive overview of all the necessary frameworks that the company should monitor. The Balanced Scorecard is one of the best-known of performance assessment framework. It's one of the most modern tools that meet the criteria established for the strategy concept of company performance evaluation (Kádárová et al, 2014).

Horváth & Partners present four perspectives of the Balanced Scorecard (Horváth & Partners, 2002, p.10, Ivanov, Avasilcăi, 2014):

1) Financial perspective: This perspective is focused on financial metrics in organization. It's very important to know where to get money and how invest them. Company should to follow wishes their investors and still monitor state and development their financial metrics.
2) Customer perspective: This perspective points to importance to meet goals company's customers. Satisfied customer is main goal every company, because leads to meeting the financial goals.
3) Internal business perspective: For meeting financial and customers goals is very important to appropriate setting internal processes. Monitoring of internal processes help to company to identify and removal problems in functioning of organization.
4) Learning and growth perspective: This perspective help company mark and exploit possible opportunities, which exist on the market. Company also must use employees and their knowledge, skills and abilities.

Four perspectives, strategy and vision of company like as a basic frame of whole approach (Figure 1).



Source: Smartdraw, 2019

Figure 1 Four perspectives of Balanced Scorecard

2.2 Approaches of articles

Many studies are focused on this perspective, but every study has different viewing angle. Because of that implementing the Balanced Scorecard into company is very difficult process, which can't cover every specific process or property, is this approach very often complement with different methods.

Study, which is focused on Innovative Integrated BSC presented that the Balanced Scorecard is now defined as a 4th Generation and say, that it's sophisticated approach, which prepare strategy for behavioral change and creating rich informed discussions about performance. They claim, that the BSC haven't a mathematical model and because of that they try integrate BSC with Data Envelopent Analysis (DEA) on a practical level. DEA is approach for evaluating the efficiency of Decision Making Units, which converts multiple inputs into multiple outputs. DEA used to measure technical efficiency (Kádárová et al, 2014).

Shafiee at al. (2014) is attempt focusing on evaluation of supply chain performance, because they say that it's one of the most complicated decision making problems. They will use four perspectives of BSC approach and combine this approach with the Decision making trial and evaluation laboratory (DEMATEL) for obtain a network structure and this structure is use for create DEA model. They say that it not possible to calculate the efficiency evaluation score by BSC. For this reason, they complement BSC approach with DEA. This approach was applied in the Iranian food industry and was successful.

Kádárová, Durkáčová and Kalafusová (2014) deal with modification of BSC. Their approach mentioned gap in the research by combining BSC, knowledge-based system (KBS) and analytic hierarchy process (AHP) method and try to fill it up. They submit a proposal on creating the Balanced Scorecard Knowledge-based System where comprises three main components of Decision Support Systems (DSSs) including Database management system, Model-base management system and Dialog generation and management system. This database includes current

or historical data, financial or non-financial information, and expert questionnaires from multiple applications or units.

Lesáková and Dubcová (2016) provide the primary research focused on detecting the current state of the knowledge and use of the Balanced Scorecard method in businesses in the Slovak Republic. Their result confirmed a presumption that not only the utilization but also the knowledge about the Balanced Scorecard method is very low in Slovak businesses. It's very likely that results of the same research carried out in the Czech Republic would be similar.

3 Key performance indicators

Key performance indicators are a discovery and well-explored way of managing enterprise performance.

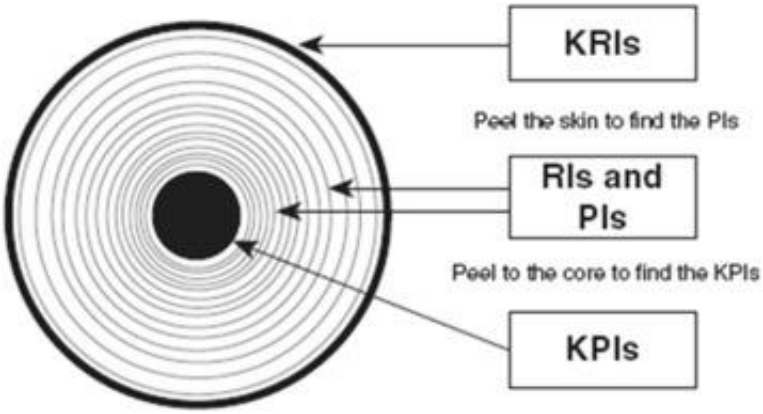
3.1 Theoretical framework

Today, the KPIs are commonly used as a tool for measuring business performance. Their introduction is linked to the organization's vision and strategic management of a business where, according to various approaches (e.g. a balanced scorecard), business management areas are defined and divided into categories that need to be tracked and measured. In these categories, the key performance indicators are then correctly selected.

Parmenter from extensive analysis and from discussions define seven characteristic of key performance indicators.

1) Non financial: Despite many different opinios, he is adamant in that all KPIs are nonfinancial.
2) Timely: KPIs should be monitored for 24 hours and seven days at week therefore, continuously.
3) CEO focus: All KPIs make a difference; they have the CEO's constant attention due to daily calls to the relevant staff.
4) Simple: All staff understand the measure and what corrective action is required.
5) Team based: Responsibility can be tied down to a team or a cluster of teams who work closely together.
6) Significant impact: Major impact on the organization (e.g., it impacts on more than one of top critical success factors and more than one balanced scorecard perspective).
7) Limited dark side: They encourage appropriate action. Before becoming KPI, a performance measure needs to be tested to ensure that it creates the desired behavioral outcome (Parmenter, 2015, p. 11-13).

There are four types of performance measures (Figure 2). Key result indicators (KRIs), which tells you how you have achieved in a perspective or critical success factor. Second are performance indicators (PIs), which tell you what must to do. Result indicators (RIs), which tell you what you have done and the last of them are KPIs, which tell you what to do to highly increase performance (Badawy et al, 2016).



Source: Badawy et al, 2016

Figure 2 Four types of performance measures

Kelvin has defined key performance indicators as "When you can measure what are speaking about and measure it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of meagre and unsatisfactory kind; it may be the beginning of knowledge but you have scarcely, in your thoughts advanced to the stage of science" (Lord Kelvin, 1870 quoted by Kaganski et al, 2017). On the other hand, Badawy et al say that many companies are working with the wrong measures, many of which are incorrectly named KPIs. Very few companies really monitor their true KPIs. That is because only few organizations, business and leaders have explored and knew what a KPI actually is (Badawy et al, 2016). Kaganski et al, in their other study add that other restriction of usage of KPIs is that it cannot be utilized in simple way to improve targets due to the fact, that each independent indicator needs to be faced to some benchmark value without concerning the remaining aspect of the company's activities, which are not related to that metric and argue that the KPIs can have a negative impact on the creativity by establishing restrictions and constraints when dealing with different issues (Kaganski, Majak, Karjust, 2018).

3.2 Approaches of articles

Pavelková et al create the study from macroeconomic point of view, which is based on the samples of original equipment manufacturers and suppliers in Czech automotive sector. Their study shows how the value-based measure represented by Economic Value Added and its pyramidal breakdown could act as facilitators in revealing value drivers. They used sensitivity analysis and the Stochastic Frontier Analysis. These analysis are based on to identify the key performance indicators. They identify how businesses react and how they are affected by the pre-crisis, crisis and post-crisis period. Their divisions divide businesses by size and their research proves that small and medium-sized enterprises are more sensitive on the changes in economy, but denies greater return of resources in these companies (Pavelková et al, 2018).

Badawi et al demonstrates different approaches for exploring key performance indicators in different directions including manual, selection, or prediction approaches supported by a theoretical framework (Badawy et al, 2016).

Hsu et al in their study identify the key performance indicators utilizes quality function deployment (QFD) approach as the basic structure in which combines with fuzzy Delphi method (FDM), modified fuzzy extent analytic hierarchy process (FEAHP) and technique for order preference by similarity to an ideal solutions (TOPSIS) method to prioritize the key performance indicators. This study is focused on small and medium-sized enterprises and their sustainability development. They say that SMEs should effectively utilize their limited resources and prioritize their performance indicators in terms of balanced scorecard approach in elaborating their sustainability development (Hsu, Chang, Luo, 2017).

Banu focuses its research on innovative SMEs. She says that when undertaking innovation, developing KPIs represents an important tool for insuring that all process objectives are met. Her study represents to establish the main requirements for developing meaningful KPIs in order to effectively measure innovation, referred to as NANOAPPARATUS. This research was implement on innovative SMEs from Romania and identified a generic methodology for developing meaningful KPIs (Banu, 2017).

Kaganski et al say that the key performance indicators are known as a powerful tool, which would provide valuable information regarding bottlenecks and weak spots in companies. They are focused on the KPIs in two studies. First, they implement the KPIs selection model as a part of the Enterprise Analysis Model, which is represented by the questionnaire for employees (number of questions and the weight of the answers depends on the employee position and the "creditability index"). The questionnaire also includes double questions that track the depth of understanding of problem. According to individual weights and indexes, the major issues in the company are evaluated and subsequently assigned to the thirteen KPIs that are designed to respect the SMARTER approach (Kaganski, Majak, Karjust, Toompalu, 2017). Follow study is based on the same thirteen KPIs respected the SMARTER approach in SMEs, but with utilize the fuzzy analytical hierarchy process. Kaganski et al calculated the KPIs weights, so how much the individual indicators meet the requirements of company's goals. Calculating is provided by the fuzzy logics. This model helps to reduce time for analysis of the company, make processes more understandable and transparent and is usable for SMEs in different industries (Kaganski, Majak, Karjust, 2018).

Collins et al describe a method for suggesting improvements to a manufacturers' KPIs, based on the results achieved from a workshop to score the KPI on a number of predefined criteria. They argued that not all KPIs are properly aligned because developing KPIs is a non-trivial task that requires a deep understanding of the businesses or operation to be done correctly, It is estimated that 70 % of performance measurement systems fail after

implementation. The authors applied the developer approach to two workshop outputs, each from independent manufacturers, and the results highlighted the significant difference between the two manufacturers in terms of improvement priorities and KPI assessment (Collins et al, 2016).

Chaharsooghi et al concerned with identifying the key performance indicators in e-commerce and determining the casual correlations among the indicators of different perspectives of the balanced scorecard in Iran. They say that applying the balanced scorecard method to identify and analyze the key performance indicators in e-commerce and virtual stores is one of the new aspects. They combine balanced scorecard and DEMATEL model. The results show that the managers should concentrate on their internal standard operating procedures in this area (Chaharsooghi et al, 2016).

Slightly different view of key performance indicators provides a study from Bobitan Roxana-Ioana, which is focused on KPIs disclosure by the Integrating reporting. This study is based on Philips Annual Report published for year 2014. Author says that institutional and small investors, financial analysts and other key stakeholders are demanding more information about long-term strategies and profitability of companies. The companies must change the way these KPIs are being incorporated throughout the annual report and how these are linked to the company's strategy and business model, their risk mitigation, and their incentive schemes. She describes which are the most important key performance indicators in sprit of integrating reporting. The results show that an integrated report should contain qualitative and quantitative reporting about how they performance leads to value creation and argue that the integrated reporting is the management tool for KPIs (Bobitan, 2016).

Articles focusing on this topic, whether macroeconomic or microeconomic, mostly combine the selection of key performance indicators with a performance management technique to prioritize these key indicators and thus give a clear message to the company that is most important to focus on. Selection, implementation and tracking of KPIs is a long-term issue that is constantly needed to measure and improve. Therefore, it is a tool of strategic management and long-term prediction of the future of the whole company.

4 Identify key performance indicators by the balanced scorecard

Some articles are older than searching concept, but their representation of the topic is very important. For this reason, older articles are worth mentioning.

4.1 Theoretical framework

To track KPIs, many companies use a Balanced Scorecard. The whole concept of key performance indicators and a balanced scorecard is to align workers' performance with the long-term strategic objectives of the company. After that company identify its vision and translating its into the strategy, company must identify targets which represented the strategy. These targets are measured by KPIs (Pacific Crest Group, 2018).

4.2 Approaches of articles

Wu implement the key performance indicators into a strategy map of the balanced scorecard for banking institutions. For the identify relationships between KPIs used the DEMATEL method. Strategy maps express casual relationships in a sequence. The chain of cause-and-effect connect all the key performance indicators through the four perspectives of BSC, which reflect dynamically the change of strategies and indicate how an organization creates its value. Key performance indicators are divided into four perspectives of BSC. The study was contributed to providing decision makers with a systematic approach for establishing a visual strategy map with a consideration of the intricate casual relationships among KPIs along with in-depth analyses of important strategic improvement paths. Author was successful in creating this system and its utilize for many organizations in different industries (Wu, 2012).

Chaharsooghi et al used the DEMATEL technique and calculated the arithmetic average of the experts' response to summarize their opinions and from this create direct and indirect correlation matrix of the key performance indicators for each perspective of BSC. They say that in this method through one of ways of creating idea in the experts, the brainstorming, the Delphi or a conference, a list of available and effective factors and criteria of the issue, should be extracted according to view of the group of participating experts (Chaharsooghi et al, 2016).

Hsu et al combine compilation of sustainable development criteria and compilation of performance indicators (based on the perspectives of BSC). Firstly, they used the fuzzy Delphi method to select important sustainable development criteria and performance indicators. Secondly, they used a modified fuzzy extent analytical hierarchy

process (FEAHP) to evaluate the weighted importance of sustainable development criteria, and the fuzzy theory measures the correlations among the performance indicators and their relationships. Finally, they used the TOPSIS for prioritization of KPIs. This study was applied to manufacturing SMEs on Taiwan, which helps create a sustainable KPI Framework with a view to improving performance (Hsu et al, 2017).

5 Future research

The state of scientific knowledge in this topic illustrates the very frequent use of key performance indicators in line with the implementation of balanced scorecard. A huge gap in this theme are non-production businesses. However, a single study has not been focused in recent years to aim on the performance measurement and the setting of key performance indicators in non-production sphere and processes. Performance measurement in non-manufacturing enterprises is just as important as in the manufacturing sphere. In a better case, non-production SMEs are themselves looking for performance management capabilities and apply already-used methods in manufacturing processes to non-productive processes, but in the worst case, and these are the overwhelming majority, these companies do not consider it important to measure, standardize or even improve their processes. And just neglecting the importance of these processes leads to a decline in performance, productivity and reduced customers satisfaction. This statement demonstrates the research conducted in SMEs in the Slovak Republic (Lesáková, Dubcová, 2016).

The literature review has found that the area of performance management, namely the KPIs and the BSC, is a topic in which new researches and combinations of different methods are being carried out. However, the gap in this area remains not only of non-productive SMEs, but also of the Czech Republic, which in recent years has no researches in this area expect the already mentioned macroeconomic perspective based on the KPIs and EVA.

The results will be used in a dissertation work. Secondary research will be conducted using the Amadeus database and primary research will take the form of a questionnaire to be send to the surveyed sample of respondents. From primary research, it will be possible to identify the key critical factors for business success. Each of these critical success factors will have to comply with SMART principle. This means that for each of these factors a probability estimate will be created and justified to what extent and why individual identifiers meet the separate criteria of this principle. The final system of proposed key performance indicators will be further broken down to the requirements of the balanced scorecard into individual quadrants, and the measurement and tracking methods for each quadrant and key performance indicators will be set. However, introducing a balanced scorecard is a very difficult task in every business, so only some parts and useful steps of this matrix will be used to link the performance key performance system. Therefore, it will be precisely decided how and how much the implementation of the balanced scorecard will take place in the KPI system. Finally, the method of tracking and measuring individual elements in the system will be selected. The ultimate output of the research will be a system of KPIs based on the balanced scorecard approach, which should be applicable in practice to the monitored enterprises. In the end, the system will be virtually implemented in one of the monitored companies and a retrospective evaluation of the whole system will be carried out.

6 Discussion

Performance management is very important tool for control company's processes. It is essential for the company to continually manage and monitor its processes and to seek continual improvement as today's economy requires.

In an ideal world, every business would monitor its performance in the same way, publishing key performance indicators and the extent to which it meets its goals and strategies. There would be a general performance management framework applicable to all businesses. However, this is not possible in the world of imperfect competition, market externalities and crisis.

The fact that the proposed system works in one industry does not mean that it will work in another industry or even in another country. Each industry is unique it its own way, and it is therefore necessary to devote in depth and thorough performance management, especially for each industry and country.

Conclusion

This article is focused on a literature review of key performance indicators, balanced scorecard and their combinations with other methods and approaches of performance management in small and medium-sized enterprises. Overview of articles and their methods (Table 1) shows that performance management is a discussed

theme, which is progressively monitored and implemented in different industries and countries. Articles are from Romania, Estonia, Egypt or USA. Research was also conducted in the Slovak Republic (Kádárová et al, 2014; Lesáková, Dubcová, 2016), but from the Czech Republic is only one paper focused on a macroeconomic point of view (Pavelková et al, 2018).

Table 1 Overview of articles

Articles and their combination of methods	Number of articles
Found in total	16
BSC/ DEA/ DEMATEL	2
BSC only	2
BSC in total	4
KPI/ EVA	1
KPI/ FUZZY methods	3
KPI/ DEMATEL	1
KPI only or other	4
KPI in total	9
KPI / BSC	3

Source: A literature review – own summarization, 2019

Only five from sixteen founded articles are focused on small and medium-sized enterprises.

Even though small and medium-sized enterprises are important to maintain economic growth. For SMEs, the adoption of advanced managerial practices in the main business processes is a key to the successful improvement of their business performance and competitiveness. According to the position of SMEs, the implementation of new theoretical performance measurement methods passes over with rational usage of internal resources. Therefore, there is a clear need to stimulate the development of performance measurement system in SMEs considering the factors characterising these companies. Besides, from the SMEs perspective, the possible ineffectiveness of informal tools might be explained by the requirement of a greater investment in term of time, funds and energy (Klovienė, Speziale, 2015). Apart of this, each of the articles focusing on SMEs is dedicated only to manufacturing businesses.

After this study, there are revealed the gaps in literature. Implications for future studies should focus on small and medium-sized non-manufacturing enterprises, their efficiency, using of performance management and, above all, the design of a performance management system based on KPIs, BSC or combination both of them that helped companies and should be practically used for these businesses. This literary research will be used for the dissertation work, with the final output of which will be a system of key performance indicators based to a balanced scorecard approach, which should be applicable in practice to the monitored enterprises. In the end, the system will be practically implemented in one of the monitored companies and a re-evaluated.

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References

BADAWY, M., ABD EL-AZIZ, A., IDRESS, A., HEFNY, H., HOSSAM, S. (2016). A survey on exploring key performance indicators. *Future Computing and Informatics Journal*, 1, 47-52.

BANU, G. S. (2018). Measuring innovation using key performance indicators. *Procedia Manufacturing*, 22, 906-911.

BOBITAN, R. I. (2016). Key performance indicators disclosures by the integrated reporting. *Academica Brâncuși*. ISSN 2344-3865.

COLLINS, A., HESTER, P., EZELL, B., HORST, J. (2016). An improvement selection methodology for key performance indicators. *Environment Systems and Decisions*, 36, 196-208.

HORVÁTH & PARTNERS (2002). *Balanced Scorecard v praxi*. [Balanced Scorecard in practice] 2nd, ed. Praha, Profess Consulting.

HSU, CH., CHANG, A., LUO, W. (2017). Identifying key performance factors for sustainability development of SMEs – integrating QFD and fuzzy MADM methods. *Journal of Cleaner Production*, 161, 629-645.

CHAHARSOOGHI, S. K., BEIGZADEH, N., SAJEDINEJAD, A. (2016). Analyzing key performance indicators of e-commerce using balanced scorecard. *Management Science Letters*, 6, 127-140.

IVANOV, C. I., AVASILCăI, S. (2014). Measuring the performance of innovation processes: A balanced scorecard perspective. *Procedia – Social and Behavioral Sciences*, 109, 1190-1193.

KÁDÁROVÁ, J., DURKÁČOVÁ, M., KALAFUSOVÁ, L. (2014). Innovative approaches to the modification of BSC model. *Procedia – Social and Behavioral Sciences*, 143, 168-173.

KÁDÁROVÁ, J., DURKÁČOVÁ, M., TEPLICKÁ, K., KÁDÁR, G. (2014). The Proposal of an Innovative Integrated BSC – DEA Model. *Procedia Economics and Finance*, 23, 1503-1508.

KAGANSKI, S., MAJAK, J., KARJUST, K., TOOMPALU, S. (2017). Implementation of key performance indicators selection model as part of the Enterprise Analysis Model. *Procedia CIRP*, 63, 283-288.

KAGANSKI, S., MAJAK, J., KARJUST, K. (2018). Fuzzy AHP as a tool for prioritization of key performance indicators. *Procedia CIRP*, 72, 1227-1232.

KLOVIENĖ, L., SPEZIALE, M. T. (2015). Is Performance Measurement System Going Towards Sustainability in SMEs? *Procedia – Social and Behavioral Sciences*, 213, 328-333.

KŘIVKOVÁ, K. (2011). *Podpora malých a středních podniků. Sofispol*. Černošice. Retrieved from: https://sophispol.webnode.cz/male-a-stredni-podniky-pateri-ekonomiky/.

LESÁKOVÁ, L., DUBCOVÁ, K. (2016). Knowledge and Use of the Balanced Scorecard Method in the Businesses in the Slovak Republic. *Procedia – Social and Behavioral Sciences*, 230, 39-48.

PACIFIC CREST GROUP. (2018). *Using a Balanced Scorecard to Measure Your Key Performance Indicators*. Overijse, Belgium. Retrieved from: https://www.pcg-services.com/using-a-balanced-scorecard-to-measure-your-key-performance-indicators/.

PARMENTER, D. (2015). *Key performance indicators: Developing, Implementing and Using Winning KPIs*. 3rd ed. Hoboken, New Jersey, John Wiley & Sons.

PAVELKOVÁ, D., HOMOLKA, L., KNÁPKOVÁ, A., KOLMAN, K., PHAM, H. (2018). EVA and key performance indicators: the case of automotive sector in pre-crisis, crisis and post-crisis periods. *Economics & Sociology*, 11(3), 78-95).

SHAFIEE, M., LOTFI, F. H., SALEH, H. (2014). Supply chain performance evaluation with data envelopment analysis and balanced scorecard approach. *Applied Mathematical Modelling*, 38, 5092-5112.

SMARTDRAW. (2019). *What is balanced scorecard?* California, USA. Retrieved from: https://www.smartdraw.com/balanced-scorecard/.

WU, H.-Y. (2016). Constructing a strategy map for banking institutions with key performance indicators of the balanced scorecard. *Evaluation and Program Planning*, 35, 303-320).

Challenges in Digital Product Development at Latvian Commercial Banks

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Abstract

Purpose of the article The purpose of the article is to determine what digital banking products are currently available to the clients in Latvia, to find out how clients assess the usefulness of these products, and to consider potential challenges commercial banks have to face while launching new digital products.

Methodology/methods The research is based on the analysis of the theoretical literature, synthesis and comparison of the Latvian banking sector data and the information included in the financial statements of particular commercial banks. Quantitative analysis based on two structured questionnaires was used to obtain empirical data. 150 completed client questionnaires and 43 expert assessments were used in the present study. Empirical data processing and analysis were performed with the help of Microsoft Office Excel software.

Scientific aim Scientific aim is to determine the most significant factors that have an impact on digital product launch and development in the financial sector. The current study contributes to the existing body of research on the challenges faced by the Latvian banking sector.

Findings Based on the research results, the challenges the banks may face introducing digital solutions have been identified. Insufficient level of client proficiency has a major influence on the application of digital solutions. Other essential factors that influence digital solution launch include client age differences and personal habits. These factors determine the differences in service use in definite client groups, as well as client opinions about service security.

Conclusions Remote client services will become more widespread and they will not be limited solely to the traditional internet banking; there will be a constant search for new methods to ensure more convenient and more efficient client service. However, to make sure the banks are able to successfully develop service channels, it is recommended to adjust them to client needs. In turn, insufficient client readiness for the application of digital solutions may both impede adoption of new digital solutions and limit client opportunities in service use.

Keywords: digitalization, technological solutions, bank clients, assessment, service channels

JEL Classification: G21, L86

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Introduction

In recent years, development of digital technologies has had a considerable impact on the financial sector, promoting improvement of the existing banking services and introduction of new financial solutions. In the last five years, Latvian commercial banks have significantly expanded their digital service range, providing their clients with the opportunity to try a variety of new technological solutions. Traditional banking services are being gradually replaced with newer and more technologically advanced ones, however, at present, client expectations regarding bank activities in the area of digitalization are not completely clear – either they expect development of yet more advanced services, improvement of the existing digital services, or there are other aspects that clients consider important.

1 Technological Development in the Financial Services Sector

Improvement of the selling process efficiency is largely connected with the management of relationships among the main stakeholders (Šimberová, 2014). Introduction of innovative financial technologies and process digitalization have become a customary management issue in the financial sector. It is the banking clients who experience it at its most, as technological development is changing the traditional banking model and the financial sector as a whole. Technologies have become an important factor in provision of financial services (Frame et al., 2004; Bons et al., 2012) and not only financial service providers but also clients should adjust to a new reality.

In a definite period, technological changes in the field of banking were mainly related to payment system transformation: cheques (1945), the first credit card (1958), ATMs (1967), Telex and SWIFT transfers (1977), debit cards (the 1980s), internet banking (the 1990s), crowd funding and cloud computing (2005), cryptocurrency, e-wallets, robotic automation and Big Data analytics (2010) (Ashta and Biot-Paquerot, 2018). At present, technologies have become an integral part of financial activities, and the work of commercial banks is greatly influenced by new market players – FinTechs (financial technology firms) (Alt et al., 2018).

It is forecasted that in the coming decade innovations in the field of financing may decrease the number of bank employees by approximately one third (Citi GPS, 2017). In turn, Accenture PLC (2014) consider that in order to succeed in the digital environment banks should be able to fully meet financial and non-financial client needs, which can be accomplished introducing innovative solutions and ensuring continuous and advanced services. Banks should evolve into "everyday banks", that is, banks should provide their clients with the services that accommodate all their needs, even if they go beyond the traditional banking service model (Zhuming et al., 2017).

The aim of the research conducted by Accenture was to discover whether the clients were ready to use banking services offered by popular enterprises (PayPal, Google, Amazon, Apple, WalMart) in case they had been provided with this opportunity. Research results (3,846 respondents) demonstrate that younger generation clients are open for application of alternative banking services, whereas older generation clients are more likely to stick to traditional banking services (Accenture, 2015). Thus, developing technological solutions banks should primarily concentrate on younger generation client needs, as it is younger generations that are subject to a more pronounced influence of innovative technologies. In turn, the research conducted by DBR Research aimed at determining the most important banking trends in 2018 showed that the most significant aspects in financial organization forecasts were as follows 1) removing client friction in service application process (61%); 2) Big Data – improved data use (57%); 3) multichannel service delivery (42%); 4) "API – standard application pro-gram interface" (35%); 5) "building partnerships between banking and financial technology enterprises (FinTech firms)" (27%); 6) "expansion of digital payments" (26%) (Marous, 2017).

Payments are becoming more integrated, banks will develop comprehensive understanding of their clients and that will allow developing more competitive offers. At the same time, innovations provide clients with the access to the previously limited assets and services, as well as ensure better product awareness and control over product selection (World Economic Forum & Deloitte, 2015).

2 Trends in Digital Product Launch in the Latvian Banking Sector

In the first half of 2018, the profit of the Latvian banking sector amounted to 133 million EUR, which is a 19% decrease compared with the results of the first half of 2017. Of 30 May 2018, the aggregate banking sector capital amounted to 3.1 billion EUR. It did not change much compared with the 1st quarter of 2018, which at-tests stability of the banking sector. The results of the 2nd quarter of 2018 summarized by Finance Latvia Association show that on the whole Latvia is still in the period of economic growth. Characterizing the Latvian banking sector it may be

mentioned that much attention is paid to the international sanction policies, as well as Anti-Money Laundering/Combating the Financing of Terrorism issues and observing the principle "Know your client" (Finance Latvia Association, 2018).

The main aim of new digital solutions is speed, mobility, security and applicability of services. The data of the Latvian banking sector demonstrate that enterprises actively use the opportunities provided by financial technologies: 1) 99% of all payments are made using internet banks or payment cards; 2) 94% of bank clients have access to electronic bill payment facility; 3) Open Banking platforms cover 70% of clients and provide access to 11 million clients in the EU and Northern Europe (Finance Latvia Association, 2018).

The Alternative Financial Services Association of Latvia confirms that 2018 witnessed rapid development of financial technologies. According to the research on the FinTech sector, the most rapid development is expected in peer-to-peer lending platforms (70%), payment systems (53%) and e-commerce (47%) (Aboltins, 2018).

Already in November 2017 the Bank of Latvia introduced the service accommodating the instant payment scheme of the Single Euro Payment Area. Using instant payments, clients can make transfers to more than 1,000 banks in the EU countries. Currently, only three Latvian commercial banks provide instant payments (Citadele, SEB and Swedbank), but it can be forecasted that along with the development of instant payment technologies banks and other financial enterprises will offer a new service to their clients – an opportunity to make payments using a mobile phone number (Helmane, 2018).

Finance Latvia Association unites 28 financial sector enterprises. In nine months of 2018, five most profitable banks were Swedbank, SEB Bank, Luminor, Citadele Banka, and BlueOrange Bank. On the whole, the categories of offered services are similar, however, there are certain differences in the range of services. Authentication tools are among the most popular digital solutions, for example, Smart-ID (Swedbanka, SEB Bank). Other banks have developed their own solutions – the clients of Luminor Bank may use "Nordea Codes" app, at the same time, the clients of Citadele Bank may use innovative services authorizing with Touch ID (touch function), Face ID (face recognition function), as well as using Mobile Scan, which allows authorizing by scanning the "color code". BlueOrange Bank has developed a mobile Digipass Blue Key that supports Touch ID and Face ID functions. Technological solutions offered by these banks are summarized in Table 1.

Table 1 Technological solutions offered by Latvian banks

Technological solutions	Name of the bank				
	Swedbank	SEB Bank	Luminor	Citadele Bank	BlueOrange Bank
Mobile application and internet bank	+	+	+	+	+
Instant payments	+	+	-	+	-
Authentication tools	Smart-ID (Basic and Qualified), eID	Smart-ID	Nordea Codes application	Touch ID, Face ID, MobileSCAN	Mobile Digipass Blue Key (with Touch ID and Face ID)
Contactless payments	Contactless smart cards, payments by telephone	Contactless smart cards	Contactless smart cards	Contactless smart cards, payments by telephone, cPay bracelet, cPay sticker	Contactless smart cards
Other	-	Digital coin jar	-	Payment card with transport e-card functions, X-card, touchscreen ATMs	Contactless smart card ATMs, remote account opening

Source: own elaboration

All banks offer contactless payments to their clients, however, Citadele Bank offers the widest range of contactless payment facilities – payments by telephone, cPay bracelet (it is possible to make payments using the bracelet), cPay sticker (telephone sticker that allows making payments).

Several banks have also developed other digital solutions, for example, client of SEB bank may use digital coin jar (the sum of each purchase made using a payment card is rounded off and the difference is transferred to the

savings account), Citadele Bank offers its clients a card with transport e-card functionality. Citadele and BlueOrange banks have introduced specific functionalities also in their ATMs – touchscreen and contactless smart card ATMs. BlueOrange Bank is the first bank in Latvia that introduced remote client identification process that allows opening an account without visiting the bank. Onsite client identification has been replaced with video counselling (BlueOrange Bank, 2018).

According to the data summarized by Finance Latvia Association, of 30 May 2018, 69.9% of all clients used internet banking, whereas on 31 December 2017 this figure was 66.7% (Finance Latvia Association, 2018). The number of internet bank users keeps growing and that suggests that clients are gradually changing their habits and get adapted to process digitalization. Of 30 May 2018, Luminor Bank reported the largest proportion of internet bank users (87%), Swedbank (82%) was ranked second, SEB Bank (68%) was ranked third, Citadele Bank (50%) was ranked fourth, whereas BlueOrange Bank (42%) finished fifth.

Digital solutions come at a considerable cost. Citadele Bank stated that in 2017 it invested more than 3 million EUR in digitalization and development of innovations (Citadele Bank, 2018). In turn, BlueOrange Bank investment in technology exceeded 1 million EUR (BlueOrange Bank, 2018).

It should be pointed out that Citadele and BlueOrange Bank have invested considerable funds in the development of digital solutions, and it can be observed that these banks reported the largest increase in the number of clients in 2018. The number of Citadele Bank clients increased by 5% in six months, whereas the number of clients of BlueOrange Bank grew by 35%. It means that process digitalization facilities attraction of new clients.

From 14 September 2019, the European Union adopted Commission Delegated Regulation 2018/389 on the technical standards regulating secure user authentication came into effect. It has very serious implications. For instance, Swedbank should ensure that code card users switch to a more secure solution – Smart-ID – until September 2019, which poses a considerable challenge for both the bank and its clients.

3 Research Methodology

The aims of the present research are to find out client and expert opinions on the digital solutions offered by the banks, to determine the level of client preparedness and the role preparedness plays in the application of new technological solutions, as well as to collect expert opinions on whether banks provide sufficient support in educating their clients. In order to reach these aims, two survey questionnaires have been designed:

1) The first survey questionnaire consists of two parts – introduction and the main part. The introduction includes description of the socio-demographic profile of respondents (age, sex). The main part comprises eleven questions, including three matrix questions (Likert scale), one ranking question (with an opportunity to rank answer variants from 1 to 4), two multiple choice questions (including an option to suggest one's own answer variant) and five closed questions.

2) The second survey questionnaire is made of two parts, the first presenting the socio-demographic profile of respondents (age, sex, respondent's work experience in the financial sector). Employees with various work experience (more than one year) were includes in the survey to be able to appreciate the differences in opinions regarding process digitalization among employees depending on the duration of their employment.

Description of respondents:

1) Respondents of the fist questionnaire were invited using social networks – Facebook and Twitter, the main eligibility criteria to take part in the survey was the presence and regular use of an account in a Latvian bank. The survey was sent out to each respondent individually – 430 questionnaires were sent and 150 questionnaires were returned, i.e. by 35% from the total number of potential respondents. Out of 150 respondents, 70% were female and 30% – male. Distributing respondents by age group, 53% of respondents were aged 26 – 35 years, 22% – under 25 years of age, 20% – from 36 to 50 years, and 5% were over the age of 50.

2) 43 bank employees answered the questions of the second questionnaire (77% were female and 23% were male). Distributing respondents by age group, 20% were in the age group 'under 25 years of age', 50% respondents fell into 26 – 35 age group, 28% were in the age group 26 – 50 years and 2% were over the age of 50. With respect to work experience, the respondents were distributed as follows: 35% respondents

worked in the financial sector for 1 – 3 years, 25% – for 3–5 years, 5% – for 5 – 10 years, and 35% of respondents reported work experience in finance exceeding 10 years.

4 Results and Discussion

In order to reach the research aims, the authors have set numerous tasks: 1) to conduct a survey among bank clients to identify client needs; 2) to conduct the survey among field experts (bank employees). That would allow discovering the habits in the use of technological solutions by clients in different age groups, determining client education level and learning about the current client needs.

High ranking of the internet banking functionality may be explained by the fact that in Latvia this facility has been used for more than 20 years, and it has been developing gradually. In turn, introduction and development of mobile apps have been rapid and they have come into active use only in recent years.

Table 2 Frequency of application of remote bank client service channels (own elaboration)

Service channel	Bank service channel application frequency			
	Very often	Often	Rarely	Very rarely
Internet bank	45%	29%	13%	13%
Mobile app	42%	45%	11%	2%
Branch of the bank	6%	14%	43%	37%
Telephone bank	8%	11%	33%	48%

Source: own elaboration

It can be seen from Table 2 that application frequency of internet banking is 45% and that of mobile apps – 42%. Internet banking and mobile apps are the main service channels that clients may use to solve emerging issues independently, not contacting the client adviser. The majority of respondents rarely use bank services at bank branches and telephone banking.

Respondent answers to the question “In your opinion, which recently introduced digital solutions are the most useful?” are presented in Figure 1.

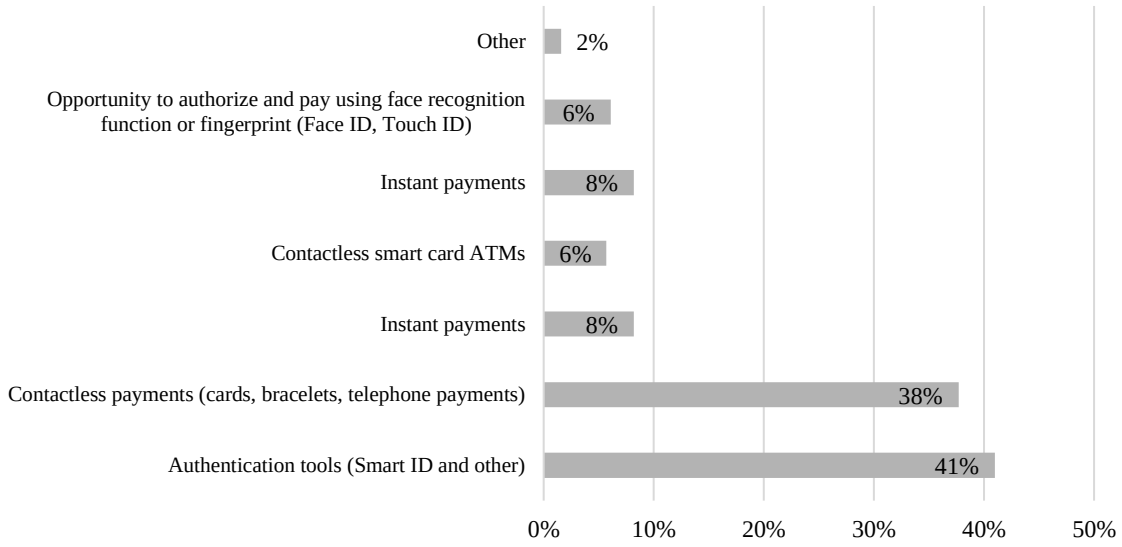

Figure 1 Assessment of the usefulness of digital solutions introduced by the bank (client assessment)

The clients ascribed the highest ranking (Fig. 1) to the authentication tools (41%) (Smart-ID and other) and contactless payments (38%) (cards, bracelets, telephone payments) – these solutions were recognized as being most useful by 79% of respondents. 8% of respondents appreciated the usefulness of instant payments, and 6% of respondents voted for the newest authentication functions – Face ID and Touch ID, as well as contactless smart card ATMs. 2% of respondents selected the option "Other", of which three people indicated that they did not use any of the mentioned services, and one person considered cash withdrawal facility as the most useful function. Authentication and payment functionality that is supported by Face ID and Touch ID is one of the newest functions, which is currently provided by only one Latvian bank, therefore, it may be assumed that only a limited number of clients have had a chance to try and evaluate this service.

Client willingness and readiness to use solutions offered by the banks is one of the determining factors while making a decision on the launch of a new solution. Clients consider authentication tools and contactless payment facilities as the most useful digital solutions offered by the banks. They mention service security, internet banking, mobile app functionality and remote service opportunities as the most important criteria in banking service use. The answers indicate that clients call for functional and user-friendly and at the same time secure financial service provision processes. The above-mentioned criteria are an inherent element of a high quality service provision process, and they should be ensured by every service provider. Client survey results demonstrate that clients do not feel sufficiently confident about service security and that may influence client decision to use a particular technological solution.

Expert answers to the question "Assess the level of bank client readiness to use digital solutions" are summarized in Figure 2.

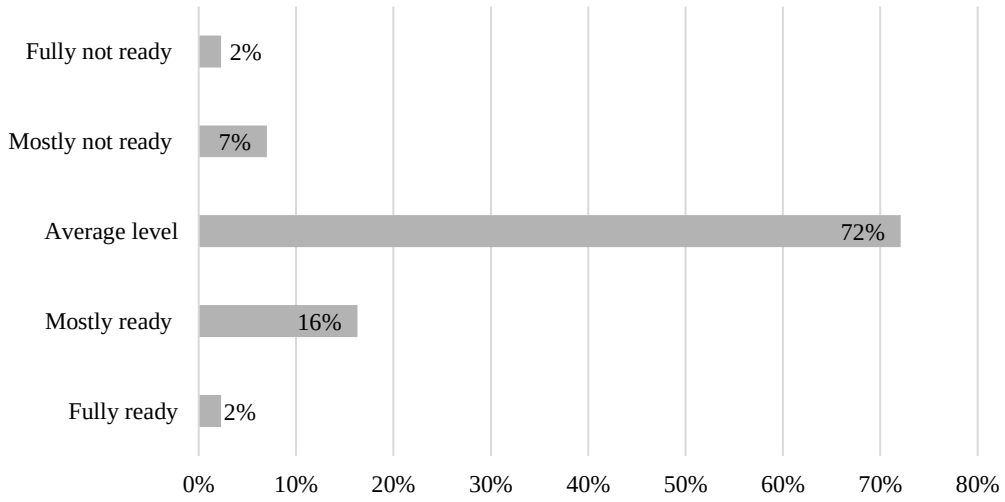

Figure 2 The level of bank client readiness to use digital solutions (expert assessment)

The majority of experts (72%) evaluate the level of client readiness as average, 16% selected the option "mostly ready", and only 2% answered "fully ready". 7% of respondents estimate client readiness level as "mostly not ready" and 2% as "fully not ready". It may be concluded that the level of client readiness is not sufficient taking into consideration rapid development of digital solutions and the essential role they play in the everyday activities of the clients, which in its turn calls for application of certain knowledge. It can be assumed that if banks intensify their involvement in educating their clients, the level of client readiness will also grow, which consequently will increase the number of users of digital solutions and motivate clients to use the newest solutions.

The experts were asked a question "In your opinion, which factor has the main influence on the scope and speed of digital banking technology development?", the answers are given in Figure 3.

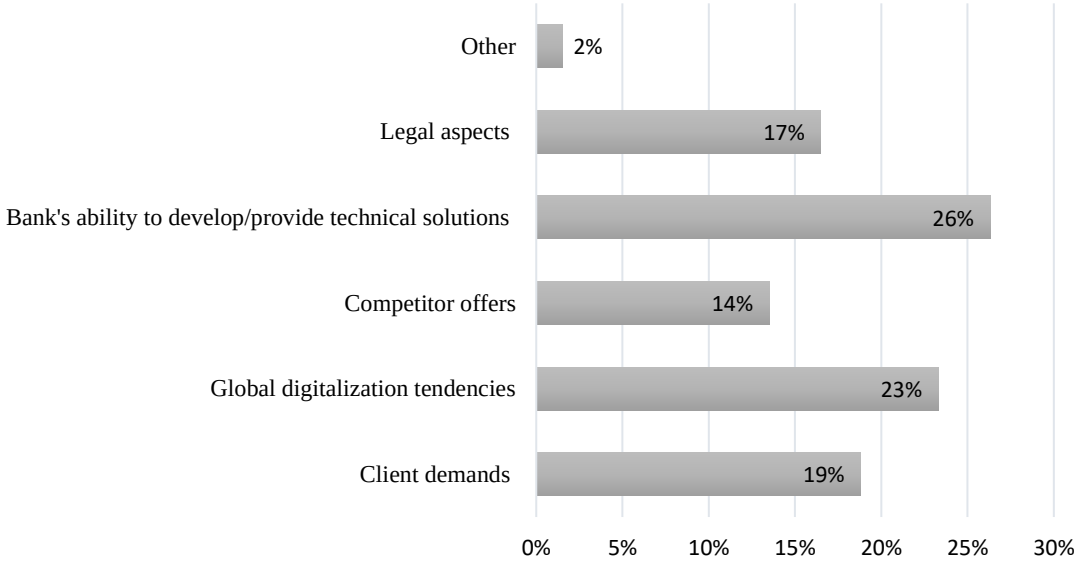

Figure 3 Correlation between the scope and speed of digital technology development and specific aspects (expert assessment)

26% of respondents selected the option "Bank's ability to develop/provide technical solutions", a slightly smaller fraction (23%) considered that introduction of new services depends on "Global digitalization tendencies", in turn, 19% selected the option "Client demands". A yet slightly smaller fraction of respondents (17%) selected the option "Legal aspects" and 14% selected the option "Competitor offers". 2% of respondents opted for the answer "Other", indicating their own answer variants – "Change of client habits" and "Bank's ability to handle security issues".

For example, code card exchange process planned by Swedbanka may be impeded by the following client-related factors: 1) poor client proficiency and low awareness of the new solution; 2) limitations in service use imposed on definite groups of clients (age, available infrastructure); 3) insufficient client confidence in the security of the used services. Despite the fact that the switching of the code card users to Smart-ID is another step to digitalization of banking services, it is important to stress that the main idea behind this move is concern about client security, and that is one of the topical bank priorities.

Customer equity is an aspect determining the total business equity, and within a business model, customer equity management is manifested as business decision-making (Kita and Šimberová, 2018). Business decisions may concern not only the clients, but also other stakeholders. A bank may outsource the functions related to educating their clients to its cooperation partners, for example, establishing cooperation with the Latvian mobile network operators guided by the following considerations:

1) mobile network operators have a wide client base and are well recognized by the clients, which distinguishes them from other service providers.
2) also clients from older generations attend service outlets of mobile network operators (mainly to settle telephone bills), and that provides the banks with the opportunity to reach this client group that needs special support in using Smart-ID.
3) sufficiently large number of customer service outlets in different Latvian cities will allow reaching a wide range of clients, and that is essential in order to ensure the necessary pace of code card exchange.
4) mobile network operators are characterized by sufficiently high level of awareness of the process digitalization, and that may become an important consideration selecting potential cooperation partners.

Mobile apps and internet bank are two most important service channels that have a large potential for development. The research attests that bank branches are losing their popularity, and digital solutions started to play an increasingly important role in client service provision. It can be mentioned that the majority of bank clients use internet banking services to settle their everyday financial issues. Mobile apps are slightly less popular, and that may be explained by limited functionality of the applications, as well as insufficient level of client awareness about functionalities of mobile apps.

It is essential to stress that a certain fraction of clients may face limitations in service provision using any of the newest banking solutions. This will mostly concern older generation clients, as well as people who do not use smart devices or those who have limited access to the internet. Service limitations may also be conditioned by insufficient client proficiency, that is, it may happen that a client does not know how to use a service and thus evades using it. Summarizing the client and expert survey results it may be concluded that bank employees face fewer difficulties adopting new digital solutions, whereas bank clients in the age group from 35 to 52 years old experience certain problems acquiring digital solutions. The above-mentioned considerations imply that irrespective of the level of digitalization of technological processes of a bank, certain groups of clients will still have the need for personal contact.

Only one third of bank clients state that digital services offered by the banks are fully comprehensible and user-friendly, at the same time, experts in their answers stress the importance of educating and informing the clients, pointing out that currently banks are not sufficiently involved in the client education process. Experts consider that provision of comprehensible user-friendly services may have a considerable impact on the client decision to use digital solutions.

It can be pointed out that assessing service criteria, experts indicated that the most popular and the most useful bank services were not considered complicated, in turn, the services in much lower demand were evaluated as complicated. This observation repeatedly points at the correlation between the demand for a service and its user-friendliness.

Conclusion

Several priorities set by the Latvian banks can be mentioned. First, if banks want to provide their clients with suitable financial solutions, it is necessary to analyze client needs. The second tendency indicates that banks will start using the newest and most advanced data collection and data processing methods and will turn their attention to automation processes and the use of artificial intelligence. The third tendency envisions development of service channels and their adjustment to client needs. It may imply that remote services will become more and more popular, and the process will not be confined to the traditional internet banking services; banks will constantly seek for new ways to ensure more convenient and more efficient customer service.

It may be concluded that the Latvian banking sector is technologically advanced and ready for process digitalization, and that is of utmost importance taking into consideration rapid technological development. Customer-centricity, needs analysis and creation of positive client experience are the main future priorities of the banks. Global development tendencies in the field of digitalization put pressure on the banks making them continuously develop innovative services, offering their clients solutions in line with the current tendencies. Banks should sustain their competitiveness not only on the local level, i.e. in Latvia, but also on the global level, therefore, they should invest considerable effort in developing and launching new services, at the same time adjusting them to the needs of the Latvian population.

The banks should also be aware of the problems they may face introducing digital solutions: 1) challenges in determining client needs – as the range of digital solutions is really wide, it may be difficult to determine which solutions and services would specifically meet the needs of the Latvian population (taking into consideration the differences in client age, personal habits and specifics of the local digital environment); 2) lack of client confidence – launching a new solution it is difficult to foresee client reaction to this solution and whether the clients will be ready to use it; 3) insufficient client preparedness for application of digital solutions – clients may experience difficulties learning how to use new digital solutions, and that may limit client opportunities to use the service.

The regulations adopted by the EU in 2018 (MiFID2, PSD2 and GDPR) definitely have an influence on process digitalization, which on the one hand promotes development of digital services, but on the other hand potentially limits service provision activities of financial institutions in case they fail to comply with effective laws and

regulations. Moreover, it may happen that process digitalization will develop faster than the legal framework regulating it and that will impede introduction of innovative services due to legislative gaps.

References

ABOLTINS, G. (2018). *Forecasts for the development of the financial technology sector in 2018. Alternative Financial Services Association of Latvia*. Retrieved from: http://lafpa.lv/lv/prognozes-finansu-tehnologiju-nozares-attistibai-2018-gada/

ALT, R., BECK, R., SMITS, M. T. (2018). FinTech and the transformation of the financial industry. *Electronic Market*, 28(3), 235-243. Doi 10.1007/s12525-018-0310-9.

ASHTA, A., BIOT-PAQUEROT, G. (2018). FinTech revolution: Strategic value management issues in a fast changing industry. *Strategic Change*, 27(4), 301-311. Doi 10.1002/jsc.2203.

BLUE ORANGE BANK. (2018). *BlueOrange becomes the first online bank in Latvia*. Retrieved from: https://www.blueorangebank.com/lv/blueorange-klust-par-pirmo-online-banku-latvija

BLUE ORANGE BANK. (2018). *In 2017 BlueOrange Bank develops new activity areas*. Retrieved from: https://www.blueorangebank.com/lv/2017-gada-blueorange-bank-attista-jaunus-darbibas-virzienus

BONS, R. W., ALT, R., LEE, H. G., WEBER, B. (2012). Banking in the internet and mobile era. *Electronic markets*, 22(4), 197-202. Doi 10.1007/s12525-012-0110-6.

CITADELE GROUP'S. (2018). *Annual report Citadele AS 2017*. Retrieved from: https://www.cblgroup.com/en/investor-relations/financial-reports/

CITI GPS. (2016). *Global Perspectives & Solutions, Digital Disruption - How FinTech is Forcing Banking to a Tipping Point*. Retrieved from: https://ir.citi.com/

FINANCE LATVIA ASSOCIATION. (2018). *Summary of performance results of the Latvian banks for the 2nd quarter of 2018*. Retrieved from: https://www.financelatvia.eu/wp-content/uploads/2018/09/Zin%CC%A7a-Latvijas-komercbanku-darbi%CC%84bas-rezulta%CC%84ti-2018.-gada-2.-ceturksni%CC%84.pdf

FRAME, W. S., WHITE, L. J. (2004). Empirical studies of financial innovation: lots of talk, little action? *Journal of economic literature*, 42(1), 116-144. Doi 10.1257/002205104773558065.

HELMANE, I. (2018). Over 90% of commercial bank customers already have access to instant payments. *Latvijas vēstnesis*. Retrieved from: https://lvportals.lv/norises/300099-zibmaksajumi-pieejami-jau-vairak-neka-90-komercbanku-klientu-2018

KITA, P., ŠIMBEROVÁ, I. (2018). An overview of business models in the Czech chemical industry: a sustainable multiple value creation perspective. *Entrepreneurship and Sustainability Issues*, 6(2), 662-676. Doi 10.9770/jesi.2018.6.2(14).

MAROUS, J. (2017). Top 10 Retail Banking Trends and Predictions for 2018. J. D. Power & Associates. *The Financial Brand*. Retrieved from: https://thefinancialbrand.com/

ŠIMBEROVÁ, I. (2014). Company strategic marketing management–synergic approach and value creating. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 58(6), 543-552. Doi 10.11118/actaun201058060543.

FINANCE LATVIA ASSOCIATION. (2018). *Technologies: Data of the banking sector of Latvia*. Retrieved from: https://www.financelatvia.eu/prioritates/tehnologijas/

ACCENTURE. (2015). *The Everyday Bank. A New Vision for the Digital Age*. Retrieved from: https://www.accenture.com/

WORLD ECONOMIC FORUM & DELOITTE. (2015). *The Future of Financial Services: How disruptive innovations are reshaping the way financial services are structured, provisioned and consumed*. Retrieved from: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf.

ZHUMING, C., YUSHAN, L., YAWEN, W., JUNJUN, L. (2017). The transition from traditional banking to mobile internet finance: an organizational innovation perspective-a comparative study of Citibank and ICBC. *Financial Innovation*, 3(1), 1-12. Doi 10.1186/s40854-017-0062-0.

Typology of Statutory Cities in the Czech Republic from the Perspective of their Indebtedness and Population

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Abstract

Purpose of the article Czech municipalities are public corporations which own property and undertake economic activity based on their approved budgets. The title "statutory city" is awarded to the largest cities of the Czech Republic, which are listed in Act Number 128/2000 Coll. The main purpose of the paper is to examine the relationship between the indebtedness of statutory cities (per capita) and their size (number of inhabitants), and the subsequent typology of these statutory cities based on these two attributes.

Methodology/methods Data were processed via standard methods of descriptive statistics, correlation analysis and cluster analysis.

Scientific aim The aim of the paper is to examine the relationship between the indebtedness of statutory cities (per capita) and their size (number of inhabitants), and the subsequent typology of these statutory cities based on these two attributes. The population factor (number of inhabitants) was selected based on bibliographical sources as well as based on data from the Ministry of Finance of the Czech Republic. The ministry itself assumes that the indebtedness of Czech municipalities is indeed related to their size: while indebtedness is not very common in the smallest municipalities (200–500 inhabitants), nearly all larger cities are indebted (with a handful of exceptions).

Findings Having calculated Spearman's correlation coefficient and the Kendall´s correlation coefficient, we can confirm a statistically significant medium dependency between the indebtedness of statutory cities and their population. Based on these results, we employed cluster analysis to generate a typology of statutory cities based on their indebtedness and size (population): three clusters were determined (S1, S2 and S3).

Conclusion We can cautiously state that the indebtedness of a Czech statutory city is related to its size, even though it is not possible to confirm with absolute certainty a statistically significant relationship based on these results.

Keywords: municipality, statutory city, indebtedness, cluster analysis, region, public administration

JEL Classification: H63, H72

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Introduction

The public administrative sector was among the first to be affected by the important post-1989 reforms; nonetheless, a long and somewhat tortuous journey was required to achieve present-day conditions. Municipalities, being the basic self-governing units, were formed as early as 1990. The form and hierarchy of higher territorial self-governing units were decided several years later (Průcha, 2011). The present-day regions were established pursuant to the Constitutional Act Number 347/1997 Coll., while the activities of regional governments were set out under Act Number 129/2000 Coll.

Pursuant to Articles 99 and 100 of the Constitution of the Czech Republic, municipalities are the basic territorial self-governing unit and every municipality is a part of a region as the higher territorial self-governing unit. The so-called mixed model of public administration established in the Czech Republic allows regions and municipalities to coordinate their respective public administrative activities (Průcha, 2011, p. 23). The status and tasks of municipalities and their authorities are governed by Act Number 128/2000 Coll., on municipalities (the Municipal Order), while the basic framework of economic activities is stipulated by Act Number 250/2000 Coll., on budgetary regulations of territorial budgets.

A municipality with at least three thousand inhabitants is a city as long as the request submitted by the municipality is granted by the Speaker of the Chamber of Deputies of the Parliament of the Czech Republic, subject to the government's concurring statement (pursuant to Section 3 of Act Number 128/2000 Coll.). Statutory cities are the largest cities of the Czech Republic, explicitly listed in Section 4 of the said act. Even though their number is relatively small (statutory cities make up only 0.5% of all Czech municipalities), their total population represents almost one quarter of the population of the Czech Republic (not including Prague). Statutory cities may be divided into districts or boroughs with their own self-governing authorities (assembly). However, only seven of the 25 statutory cities are actually divided in this way.

Pursuant to Act Number 128/2000 Coll., municipalities are public corporations which own property and carry out economic activities under the conditions stipulated by the said act and within the framework of their budgets. In legal relations, municipalities act on their own behalf and bear responsibilities arising from these relations. The state is not responsible for the economic activity or liabilities of municipalities, but it can assume these liabilities on the basis of a contract (Section 38 of Act Number 128/2000 Coll.). Czech municipalities have very limited tax authority: within the framework of the applicable legislation they may only impose real estate tax and local fees. Therefore, they depend to a great extent on transfers from the state budget, in particular receiving their share in so-called shared taxes (value added tax, corporate income tax, individual income tax) (see Section 4 of Act Number 243/2000 Coll.).

The economic activity of a municipality is kept under internal and external review. The highest authority of internal review is the assembly of the municipality, while a mandatory external annual review is carried out by an auditor or the Regional Authority (depending on the size of the municipality). Furthermore, the Ministry of Finance of the Czech Republic monitors the economic activity of municipalities. Every year the ministry calculates a set of information and monitoring indicators for all municipalities and evaluates the results. Should the ministry identify a potential problem in the case of a particular municipality, the municipality in question is first notified by a letter from the minister and, subsequently, offered assistance with an analysis of the problem. In other words, the Ministry of Finance of the Czech Republic does not have leverage enabling it to limit ineffective economic management of municipalities, or to regulate their indebtedness, as the legislation of the Czech Republic does not stipulate or establish procedures in the event of municipal insolvency. An attempt to regulate the indebtedness of municipalities can be seen in the form of the adoption, after heated debate, of Act Number 23/2017 Coll., on the rules of budgetary responsibility, effective as of January 2018.

1 Survey of the relevant literature

In fact, public economy theorists do not oppose indebtedness, whether in terms of the state, regions or municipalities (Buchanan, 1998), (Stiglitz, 1997), (Musgrave and Musgrave, 1994); they do, however, recommend that regular expenditure be financed from current income (mainly from taxes, of course), while capital expenditure is financed from capital revenue – including loans or revenue from bonds issued. That being said, indebtedness (in the form of a loan or issued bonds) is generally admissible only during a recession or in relation to investment. Moreover, it is recommended that public investments are financed from a loan extended over a longer period (the debt is being repaid while the investment is being used) (Musgrave and Musgrave, 1994, p. 513). A similar opinion, i.e. that local investment projects ought to be financed via debts, is voiced e.g. by Holtz-Eakin (1991) and Cropf

and Wendel (1998). Some authors (Stavins et al., 2003) also mention debt sustainability. Even though this term is admittedly somewhat vague, it can be understood as the ability and willingness of (local) governments to repay the debt and to refrain from increasing it in future (Botoc et al., 2011).

Many authors have researched factors affecting the indebtedness of regions and municipalities. With respect to conditions in the United States, Kiewiet and Szakaty (1996) write that the level of indebtedness of municipalities is affected by personal income per capita and the left-leaning government. Other authors take into consideration more socio-economic factors (e.g. population, percentage of immigrants, transfers and tax revenue etc.) (Guillamón et al., 2011). The same authors once again confirm the correlation between population and expenditure, but they also acknowledge the fact that such expenditure always increases one year prior to municipal elections (Guillamón et al., 2013). Increasing demands in the public sector (and the resulting indebtedness) stemming from population growth is mentioned by Rivers and Yates (1997), or by Wei-Te (1995) in the case of cities with a strong focus on tourism (although tourism stimulates economic growth, it also causes an increased burden on the local public sector).

In the Czech Republic, one inspiring text has focused on factors affecting indebtedness in the villages of the Pardubice Region (Hájek and Hájková, 2009). Its authors identified the effect of several factors as statistically significant, including population, fiscal autonomy (own sources of revenue), government supervision and a variety of local political factors. In contrast, the correlation between personal income and indebtedness proved to be statistically irrelevant.

2 Purpose of the paper, data source and methodology

The subject matter of this work is the indebtedness of 25 statutory cities in the Czech Republic. Prague was not included in the data set due to its very specific nature and size, which would have compromised the results (besides, it is both a city and a region).

The main purpose of the paper is to examine the relationship between the indebtedness of statutory cities (per capita) and their size (number of inhabitants), and the subsequent typology of these statutory cities based on these two attributes. The population factor (number of inhabitants) was selected based on bibliographical sources (Guillamón et al., 2011), (Guillamón et al., 2013), (Hájek and Hájková, 2009), (Rivers and Yates, 1997), as well as based on data from the Ministry of Finance of the Czech Republic. The ministry itself assumes that the indebtedness of Czech municipalities is indeed related to their size: while indebtedness is not very com-mon in the smallest municipalities (200–500 inhabitants), nearly all larger cities are indebted (with a handful of exceptions) (https://mfcr.cz).

Due to the nature of the topic under review, only secondary data sources were available: data on the number of inhabitants and indebtedness of statutory cities was obtained from monitoring conducted by the Ministry of Finance of the Czech Republic (https://monitor.statnipokladna.cz). As indebtedness may fluctuate year-on-year, the analysis is based (in the case of all statutory cities) on the average indebtedness per capita over the period of 2010–2017. The selection of this period was not accidental: it was chosen since this was the period in which the effects of economic recession manifested in the form of problems for municipalities due to lower transfers from the state budget, i.e. from national tax revenue. Furthermore, in 2012, changes in appropriation rules came into effect, resulting in a lower share of national VAT revenue going to municipalities.

Averages from the years 2010–2017 were once again used as data for the number of inhabitants of statutory cities. These data were processed via standard methods of descriptive statistics, correlation analysis and cluster analysis.

3 Results and discussion

Of the total number of municipalities in the Czech Republic, 3,262 of them were in debt (i.e. 52.2%). Pursuant to Section 17 of Act Number 23/2017 Coll., on the rules of budgetary responsibility (which stipulates that the debt of a territorial self-governing unit may not exceed 60% of the average amount of its revenue over the last four years), 456 municipalities did not meet the criteria. Based on the monitoring conducted by the Ministry of Finance of the Czech Republic, only six municipalities carried out their economic activities at higher risk levels in 2017 (see https://mfcr.cz). The overall indicators of indebtedness are presented in Table 1.

Table 1 Summary of indicators of indebtedness of Czech municipalities

	2006	2008	2010	2012	2014	2016	2017
Total indebtedness (bln CZK)	80.9	80.1	83.3	90.0	88.9	71.9	69.0
Share of the four largest cities (%)	58.6	57.2	48.1	50.6	51.0	46.3	45.1

Source: Ministry of Finance of the Czech Republic

The highest level of indebtedness is shown for the period of 2012–2015, since which time it has been falling. Between 2012 and 2014, the Czech Republic experienced a lengthy economic crisis whose effects included lower tax revenue for public budgets. Furthermore, an amendment to the Act on Budgetary Allocation of Revenues came into force, which granted municipalities a smaller share in the national revenue from VAT. Even carrying out minor infrastructural renovations meant that municipalities were forced into greater indebtedness.

Traditionally, the four largest Czech cities (Prague, Brno, Plzeň and Ostrava) represent the highest proportion of overall indebtedness. Even though their contribution to overall indebtedness has been decreasing over the last few years, it is still significant. The largest share of total indebtedness is represented by bank loans (in 2017, 49.5%) and municipal bonds (in 2017, 10.4%). It should be noted, however, that only two cities issued bonds (Prague and Liberec), while other cities found it more convenient to take out "standard" loans or to apply for refundable financial assistance (e.g. from the state's extra-budgetary funds).

Loans from banks are typically used for renovation and building technical infrastructure, for pre-financing investment projects co-financed from European funds, or for the renovation and development of public housing. Other purposes include renovation of schools or sporting and other public facilities. These loans carry a relatively low interest rate and offer long maturity periods, which is why they are so convenient for municipalities in every respect.

3.1 Results of descriptive statistics

The basic results of the descriptive statistics for the 25 statutory cities in the Czech Republic are as follows:

Table 2 Descriptive statistics results

	Indebtedness per capita (CZK)	Average population
MIN	0	44,255
MAX	20,459	376,331
Median	7,477	67,161
Standard deviation	5,087	79,646
Coef. of variation	64.23	86.37
Top quartile	4,801	50,360
Bottom quartile	8,558	93,798

Source: Own calculation based on data from the Ministry of Finance

Here we can see significant differences among Czech statutory cities in terms of their indebtedness per capita: on one hand is the City of Teplice, with long-term zero indebtedness (the "0" figure in the table), on the other is the City of Liberec, with a debt of CZK 20,459 per capita (the MAX value in the table). The value of the coefficient of variation is interesting, as it suggests significant inhomogeneity of Czech statutory cities in terms of indebtedness per capita. In fact, even the value of standard deviation suggests the same: the absolute variability of cities from the perspective of indebtedness per capita is very high. This is even more significant in the case of figures related to average population levels: the minimum and maximum values, the values of the coefficient of variation and standard deviation all show that the set of statutory cities is inhomogeneous. There are smaller cities – the MIN value is that of Mladá Boleslav, as well as the largest cities (not including Prague) – the MAX value is that of Brno.

3.2 Results of correlation analysis

We used Spearman's rank correlation coefficient to determine the relationship between the rankings of individual variables. The result is as follows (Table 3):

Table 3 Spearman's rank correlation coefficient

	Indebtedness per capita	Number of inhabitants
Indebtedness per capita	1.000000	0.607692
Number of inhabitants	0.607692	1.000000

Note: The significance of these correlations is $p < 0.05$

Source: Own calculation based on data from the Ministry of Finance

Based on the values of Spearman's rank correlation coefficient, we can declare a statistically significant medium strength correlation between indebtedness per capita and the size of a city (population). These results for Czech statutory cities correspond to theories according to which the size of a city is a factor of its indebtedness (Guillamón et al., 2013), (Hájek and Hájková, 2009), (Rivers and Yates, 1997).

To complete the picture, in our analysis we also calculated the Kendall´s rank correlation coefficient. The results (see Table 4) only supported the aforementioned conclusion: there is a medium strength statistical significance for the correlation between the paired variables of indebtedness per capita and the size (population) of a city.

Table 4 Kendall´s rank correlation coefficient

	Indebtedness per capita	Number of inhabitants
Indebtedness per capita	1.000000	0.433333
Number of inhabitants	0.433333	1.000000

Note: The significance of these correlations is $p < 0.05$

Source: Own calculation based on data from the Ministry of Finance

3.3 Results of cluster analysis

To be included in the cluster analysis, variables must have shown at least medium strength dependence. Based on the results of the correlation analysis, we can still work with both variables, i.e. indebtedness per capita and population. As data are given in different units (Czech crowns, number of inhabitants) and show different levels and variability, we carried out standardisation to make sure that both variables had the same effect on the results of clustering. The Euclidean distance square was chosen as the measure of distance; Ward's method was applied to construct the clusters.

Three clusters were determined based on evaluating the clustering results:

Table 5 Cluster analysis results

Cluster	Number of cities	Cities
S1	6	Ostrava, Brno, Liberec, Olomouc, Ústí nad Labem, Plzeň
S2	6	Prostějov, Teplice, Most, Děčín, Jihlava, Pardubice
S3	13	Frýdek-Místek, Zlín, Havířov, Hradec Králové, České Budějovice, Přerov, Mladá Boleslav, Jablonec nad Nisou, Karviná, Karlovy Vary, Opava, Chomutov, Kladno

Source: cluster analysis

Cities in cluster S1 are very different from the rest: these are the largest Czech cities with the highest indebtedness per capita. Three of these cities (Brno, Ostrava, Plzeň) are among the four (the fourth being Prague, which is not included in the analysis) cities whose total indebtedness represents approximately 50% of the total indebtedness of towns and villages in the Czech Republic. Liberec is the city with the highest indebtedness per capita, followed by Olomouc and Ústí nad Labem. All of these cities, with the exception of Olomouc, are divided into boroughs or self-governed districts. All of these cities have a significant share of student population (living in the city only a part of the year with no permanent residence).

Cities in cluster S2 are generally medium-sized cities with an average population of 58,830 (if Pardubice is not included, the average population is only 52,636) and show a low level of indebtedness (with Teplice as the only statutory city with zero indebtedness). It is definitely worth noting that three of the cities (Most, Teplice and Děčín) in this cluster are located in the Ústí Region, which shows above-average values of indebtedness per capita compared with other regions.

Cities in cluster S3 are larger, on average, than the cities in cluster S2 (with 62,500 inhabitants), but their indebtedness is significantly above average. This cluster is the largest of the three, but also the most homogenous.

From the results we can cautiously conclude that a correlation exists between the size of a city (number of inhabitants) and its indebtedness. Indeed, the highest indebtedness is found in the largest Czech cities and below-average indebtedness in small and medium-sized cities. However, the set does contain some anomalies: e.g. Pardubice (cluster S2), one of the larger cities (almost 90,000 inhabitants), shows a low degree of indebtedness, whereas Karlovy Vary or Jablonec nad Nisou, which are somewhat smaller (50,000 or 45,000, respectively), show very high indebtedness per capita. Therefore, other individual factors, rooted in the past decisions of the cities' assemblies, are still playing a role.

Conclusion

First it is necessary to note that indebtedness of municipalities in the Czech Republic is not an exceptionally urgent economic problem. According to data from the Ministry of Finance of the Czech Republic 52.2 % of the total number of municipalities are indebted, but only six municipalities carried out their economic activities at higher risk levels. So it can be said that the economic management of the municipalities is relatively prudent.

The conclusions from our analysis vis-à-vis the purpose of this paper can be summarised as follows: based on a correlation analysis, we have cautiously concluded that a relatively close relation may exist between indebtedness per capita and the size of a city. Having calculated Spearman's correlation coefficient and the Kendall´s correlation coefficient, we can confirm a statistically significant medium dependency between the indebtedness of statutory cities and their population. Based on these results, we employed cluster analysis to generate a typology of statutory cities based on their indebtedness and size (population). In line with the results of other studies (Guillamón et al., 2013; Hájek and Hájková, 2009; Rivers and Yates, 1997), we can conclude that, in the Czech Republic, the size of a Czech statutory city is one of the factors affecting indebtedness.

Ultimately, however, it should be noted that these results are not particularly conclusive. This may be due to the low number of cities in the sample – because we wanted to retain a compact sample, we restricted the analysis to only statutory cities (the taxonomy of statutory cities is defined pursuant to Act Number 128/2000 Coll.). It would therefore be interesting to see this analysis done on a larger sample, one which would include so-called municipalities with extended powers or municipalities with an authorised municipal office.

References

Act no. 128/2000 Coll.

Act no. 129/2000 Coll.

Act no. 243/2000 Coll.

Act no. 250/2000 Coll.

Act no. 23/2017 Coll.

BOTOC, C., PIRTEA, M., NICOLESCU, C. (2011). Public Debt Sustainability Analysis: EU Case. *Annals of the University of Oradea: Economic Science*, 1(1), 409-415.

BUCHANAN, J. M. (1998). *Veřejné finance v demokratickém systému*. [Public finance in democratic system] 1st ed. Brno: Computer Press.

CONSTITUTIONAL ACT no. 1/1993 Coll.

CONSTITUTIONAL ACT no. 347/1997 Coll.

CROPF, R. A., WENDEL, G. D. (1998). The Determinants of Municipal Debt Policy: a Pooled Time-series Analysis. *Environment and Plannning C: Government and Policy*, 16(T), 211–224.

GUILLAMÓN, M. D., BASTIDA, F., BENITO, B. (2011). Evalución de la deuda pública local en España. *Revista Española de Financiación y Contabilidad*, 251-285.

GUILLAMÓN, M. D., BASTIDA, F., BENITO, B. (2013). The ellectoral budget cycle on municipal policy expenditure. *European Journal of Law and Economics*, 36(3), 447–469.

HÁJEK, P., HÁJKOVÁ, V. (2009). Debt analysis of Czech municipalities. *Scientific papers of the University of Pardubice. Series D*, 14, 36-42.

HOLTZ-EAKIN, D. (1991). Bond Market Conditions and State-Local Capital Spending. *National Tax Journal*, 44(4), 105–120.

KIEWIET, D. R., SZAKATY, K. (1996). Constitutional Limitations on Borrowing: An Analysis of State Bonded Indebtedness. *Journal of Law, Economics and Organization*, 12(1), 62–97.

MINISTRY OF FINANCE OF THE CZECH REPUBLIC. (https:// mfcr.cz, https:// monitor.statnipokladna.cz).

MUSGRAVE, R. A., MUSGRAVE, P. B. (1994). *Veřejné finance v teorii a praxi*. [Public finance in theory and practice] 1st ed. Praha: Management Press.

PRŮCHA, P. (2011). *Místní správa*. [Local municipality] 1st ed. Brno: Masarykova univerzita.

RIVERS, M. J., YATES, B. M. (1997). City Size and Geographic Segmentation in the Municipal Bond Market. *The Quaterly Review of Economics and Finance*, 37(3), 633–645.

STAVINS, R. N., WAGNERA. F., WAGNER, G. (2003). Interpreting sustainability in economic terms: dynamic efficiency plus intergenerational equity. *Economics Letters*, 79(3), 339–343.

STIGLITZ, J. E. (1997). *Ekonomie veřejného sektoru*. [Economy of public sector] 1st ed. Praha: Grada Publishing.

WEI-TE, E. H. (1995). Revenue Structure and the Size of Government: the Canadian Experience. *Public Finance*, 50(1), 80–95.

Expenditures for Employees within Local Unit Budget

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Abstract

Purpose of the article Purpose of the article is to research the effecting and share of expenditures for employees within the expenditures and expenses of local and regional self-government units, make conclusions on their significance and determine the tendency of changes in said expenditures and expenses in the period from 2015 to 2017. This paper determines the share of expenditures for employees in effected expenditures at the level of all units and the share of expenditures for employees in total expenditures and expenses at each level, i.e. at the county, town and municipality level. The amount and share of expenditures for employees in total expenditures of each county in the Republic of Croatia is examined as well.

Methodology/methods Method used in the paper is the analysis of total expenditures and expenses of all local units combined with relative figures (indices) and percentages. The correlation analysis method investigates the correlation between total expenditures and expenditures for employees. The method of comparing collected data for the period from 2015 to 2017 is used as well. Based on the collected data, all data has been consolidated and conclusions on changes in the expenditures for employees at levels of government, as well for each county, have been drawn. Data used in this research is the data of the Ministry of Finance, which is available on its webpages relating to budget execution at individual levels of government, as well as data collected from scientific literature.

Scientific aim Scientific aim is to research the amount of total effected expenditures by individual levels of government and to research the share of individual counties in total effected expenditures. The assumption is that the expenditures for employees have a significant share in total effected expenditures and expenses at the local unit level. Said expenditures must be monitored to determine how they change because local units must meet the public needs under their competence by using available budget funds.

Findings Findings confirm the assumption that the share of expenditures for employees at the level of individual local units varies and that said share is significant. The share of expenditures for employees in total effected expenditures and expenses has decreased. Expenditures for employees at the municipality level have the most significant share in total effected expenditures and expenses of all local units. Expenditures for employees at the level of individual counties are significant and their share in individual counties varies. The assumption on the correlation between employee expenditures and the size of total expenditures was confirmed.

Conclusions Conclusions relate to the necessity of decreasing expenditures for employees in total expenditures and expenses. Based on the conducted research of the amount of effected expenditures and expenses at the county level, it is visible that operating expenditures account for the most significant share in total effected expenditures and expenses. Research presented in this paper is aimed at financial indicators, whereas future research should be aimed at determining the number of employees in local units. The number of employees is not easily reduced. State and public institutions depend on IT systems and state auditors must pay attention to the reliability of computer data that is processed, maintained and reported through IT systems.

Keywords: audits, local and regional governments, budget, expenditures, expenditures for employees

JEL Classification: M42, H7

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Introduction

Local and regional self-government units adopt the budget, in which they determine budgetary revenues and budgetary expenditures. Based on determined purposes, it is ensured that the budget is executed in accordance with budgetary revenues. The effecting of budgetary revenues must be constantly monitored. Local units must meet public needs under their competence by using available budget funds, for which they must implement the principle of efficiency and cost-effectiveness, as well as the principle of efficacy. Effected expenditures also include the expenditures for employees, which must be monitored to determine how they change within effected expenditures and expenses at the level of local and regional self-government units. The aim of this paper is to research the effecting and share of expenditures for employees within the expenditures and expenses of local and regional self-government units and to make conclusions on their significance. The assumption is that the expenditures for employees have a significant share in total effected expenditures and expenses at the local unit level. Data of the Ministry of Finance, which is available on its webpages relating to budget execution at individual levels of government, as well as data collected from scientific literature was used in this paper.

1 Expenditures and expenses

Firstly, when analysing expenditures and expenses, it is necessary to define these terms and explain basic characteristics of how they are recorded. Provisions of Article 20 of the Ordinance on Budgetary Accounting and Chart of Accounts (Official Gazette 124/14, 115/15, 87/16 and 3/18), define expenditures as decreases of economic benefits in the form of a reduction of assets or an increase of liabilities, whereas expenses are defined as outflows of cash and cash equivalents on all bases. Expenditures are generally divided into operating expenditures and expenditures for acquisition of non-financial assets. Operating expenditures include expenditures for employees, material expenditures, financial expenditures, subsidies, foreign aid and general budget support, benefits and other expenditures. Expenditures for acquisition of non-financial assets include acquisition of non-financial assets (land, buildings, equipment, vehicles and other). Budgetary expenditures and expenses effected may be analysed at the state and local levels, i.e. according to the level of funding public needs. The aim of this paper is to determine the amount and significance of expenditures for employees within budgetary expenditures and expenses of local and regional self-government units, as well as changes thereof in the period between 2015 and 2017. Likewise, the legal basis for effecting expenditures for employees is examined. Expenditures for employees and the amount thereof within total expenditures and expenses effected are examined and presented based on the type of expenditures and expenses (Table 1). Expenditures for employees are examined according to effecting thereof and according to the type of local unit, which includes effecting of expenditures at the level of all counties, at the town level and at the municipality level (Table 3). The third aspect presented in this paper are the effected expenditures for employees within total effected expenditures for each of the counties (Table 6). Based on the data collected, calculation of shares of expenditures for employees were made and indices were calculated. A comparison was made of the data collected and a conclusion was made in regard its significance.

2 Total expenditures and expenses effected

This section provides an overview of total expenditures and expenses effected at the level of all counties and the City of Zagreb. Total expenditures and expenses were analysed according to individual types, i.e. depending on how much of the budget funds was spent on operating expenditures, how much was spent on expenditures for acquisition of non-financial assets, and how much was spent on financial assets and loan repayments. Table 1 provides an overview of expenditures and expenses effected in all counties and the City of Zagreb in the period between 2015 and 2017, according to the type of expenditures and expenses. The absolute amount of total expenditures and expenses per county increased in almost all counties in 2017 in comparison with 2016, as well as in comparison with 2015.

Table 1 Expenditures and expenses effected in all counties and the City of Zagreb, 2015 – 2017 according to the type of expenses and expenditures (in HRK)

	Indebtedness per capita	Number of inhabitants
Indebtedness per capita	1.000000	0.607692
Number of inhabitants	0.607692	1.000000

Source: author, according to the data of the Ministry of Finance

According to the data from Table 1, the shares of individual types of expenditures in total expenditures and expenses of the counties, towns and municipalities have been calculated. Also, relative figures (indices) have been calculated by comparing the expenditures and expenses effected in 2016 and 2017 with those effected in 2015 as the base year. Data in Table 2 indicates that the share of expenditures for employees in total expenditures had a tendency decrease in the observed period (9.27% in 2015, 8.88% in 2016 and 8.68 in 2017), whereas the indices above 100 indicate an increase in 2016 and 2017 in comparison with 2015. The share of expenditures for employees in the budgets of local and regional self-government units in Croatia and the City of Zagreb for 2008 is 16.4% (Čulo, 2011, p. 285). Consequently, we conclude that the share of expenditures for employee names tends to decrease.

Table 2 Expenditures and expenses effected in all counties and the City of Zagreb, 2015 – 2017 according to the type of expenses and expenditures, relative figures

No.	Expenditures	2015	2016	2017
1	Operating expenditures	18,974,743,520	19,467,401,065	20,494,497,247
a)	Expenditures for employees	2,109,607,328	2,130,689,730	2,170,856,826
b)	Material expenditures	5,652,828,550	5,878,811,757	6,065,996,273
c)	Financial expenditures	323,362,240	291,302,699	264,152,687
d)	Subsidies	1,034,325,290	1,063,235,399	1,149,035,539
e)	Aids	5,952,086,092	6,183,606,856	6,655,975,158
f)	Benefits to citizens and households	1,175,137,383	1,175,628,676	1,379,300,825
g)	Other expenditures	2,727,396,637	2,744,125,948	2,809,179,939
2	Expenditures for acquisition of non-financial assets	2,812,074,069	3,519,061,292	3,482,875,265
3	Expenses for financial assets and loan repayments	972,379,314	1,017,888,586	1,059,616,789
TOTAL		22,759,196,903	24,004,350,943	25,036,989,301

Source: author, according to the data from Table 1

Operating expenditures have the most significant share within expenditures and expenses effected in 2017 (81.87%), followed by expenditures for acquisition of non-financial assets (13.91%) and expenses for financial assets and loan repayments (4.22%). In 2016, the share of operating expenditures remained the most significant and its amount was approximately the same (81.10%). These were followed by expenditures for acquisition of non-financial assets (14.66%), whereas the expenses for financial assets and loan repayments had the lowest share (4.24%). In 2015, the share of operating expenditures was the most significant (83.37%), followed by expenditures for acquisition of non-financial assets (12.36%), whereas the expenses for financial assets and loan repayments had the lowest share (4.27%). In comparison with 2015, almost all expenditures had a tendency increase in 2017 and 2016, with the exception of financial expenditures, which is visible from calculated base indices. Expenditures for employees are recorded within the operating expenditures. It is visible that the share of expenditures for employees in total expenditures and expenses decreased, although the expenditures for employees have a tendency increase in their absolute amounts. Regarding the expenditures for employees, their share amounted to 8.68% in 2017, 8.88% in 2016 and 9.36% in 2015.

3 Total effected expenditures by levels of local government

Below is an overview of effected expenditures and expenses according to the levels of local government. This includes effected expenditures of the towns, counties and municipalities in total effected expenditures. The paper examines the share of the towns, municipalities and counties in total expenditures and expenses effected at the state level. This is followed by an overview of effected expenditures and expenses for employees and a calculation of the share of expenditures for employees in the observed period at the county level.

3.1 Effected expenditures for employees by levels of government

It is important to determine effected expenditures by levels of local government to conclude which level of government has the largest share in the funding of public needs. Business operations of local importance in the Republic of Croatia are funded on three levels of local government: counties, towns and municipalities. In regard to the listed data, it is necessary to note the information related to the territorial division of the Republic of Croatia which pertains to the number of local units. The territory of the Republic of Croatia is divided into 20 counties as units of regional self-government, into towns and municipalities as units of local self-government (there is a total of 126 towns and 428 municipalities), and into the City of Zagreb, which has special status as both city and county. This means that there is a total of 555 units of local self-government and a total of 576 units of local and regional self-government (Act on the Territories of Counties, Towns and Municipalities in the Republic of Croatia, Official Gazette 86/06). A different number of towns and municipalities is found in the territory of each county. The most numerous are municipalities whose scope of self-government activities relates to: development of settlements and housing, physical and urban planning, utilities, childcare, welfare, primary healthcare, primary education, culture, physical education and sports, consumer protection, protection and improvement of the environment, fire protection and civil protection, traffic in their territory and other activities in accordance with special legislation (Article 19 of the Act on Local and Regional Self-Government).

Table 3 presents an overview of total expenditures and expenses effected and of expenditures for employees according to expenditures and expenses effected at the level of all counties and the City of Zagreb, at the county level, at the level of towns and municipalities combined, individually at the town level and individually at the municipality level. Table 4 contains a calculation of the share of expenditures for employees in total expenditures and expenses of the counties, towns and municipalities according to the data from Table 3.

Table 3 Expenditures and expenses effected in all counties and the City of Zagreb, 2015 – 2017 according to the type of expenses and expenditures (in HRK)

No.	Expenditures	2015	2016	2017
1	Total all counties and City of Zagreb (20 counties + City of Zagreb)	22,759,196,903	24,004,350,943	25,036,989,301
1.1	Expenditures for employees	2,109,607,328	2,130,689,730	2,170,856,826
2	Total expenditures and expenses – COUNTIES (20 counties)	3,769,173,005	3,763,387,771	4,042,057,507
2.1	Expenditures for employees	363,945,830	358,431,056	356,109,348
3	Total expenditures and expenses - TOWNS AND MUNICIPALITIES (554 towns and municipalities)	18,990,023,898	20,240,963,172	20,994,931,794
3.1	Expenditures for employees	1,745,661,498	1,772,258,674	1,814,747,478
4	Total expenditures and expenses – TOWNS (126 towns)	15,167,749,172	16,281,722,950	16,821,168,494
4.1	Expenditures for employees	1,306,697,863	1,325,881,471	1,368,326,993
5	Total expenditures and expenses - MUNICIPALITIES (428 municipalities)	3,822,274,726	3,959,240,222	4,173,763,300
5.1	Expenditures for employees	438,963,635	446,377,203	446,420,485

Source: author, according to the data of the Ministry of Finance

Also, relative figures (indices) have been calculated by comparing the expenditures and expenses effected in 2016 and 2017 with those effected in 2015 as the base year. Data in Table 4 indicates that the share of expenditures for employees by individual levels of governments ranges from 8.13% at the town level in 2017 to 9.66% at the county level in 2015. The same author states that, for small municipalities with 29 and having up to

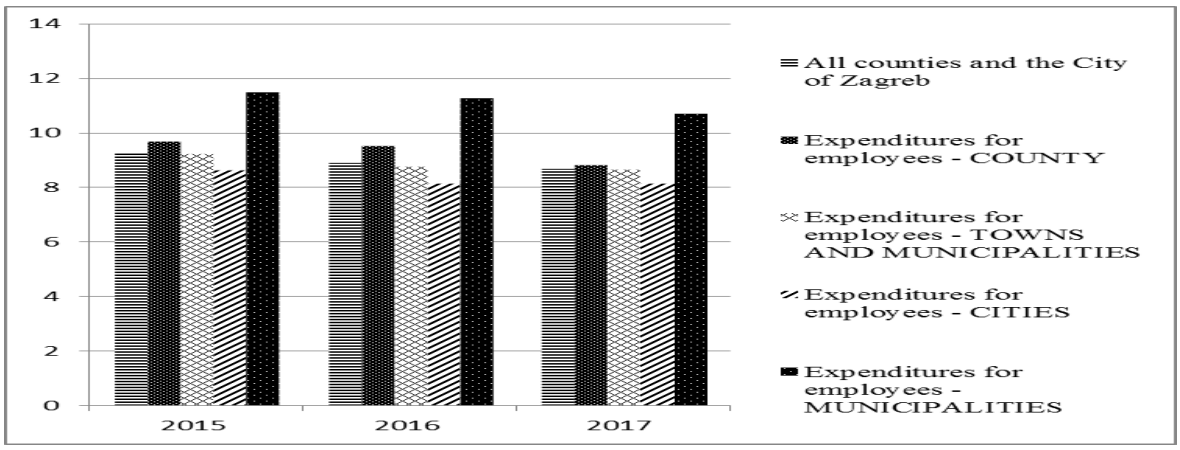
1 000 inhabitants, the average share of expenditures for employees in total expenditures in 2007 was 10.4% (Čulo, 2011, p. 294). At the level of all counties and the City of Zagreb, the share of expenditures for employees saw a decrease (8.68% in 2017, 8.88% in 2016 and 9.27% in 2015). At the county level, the share of expenditures for employees saw a decrease (8.81% in 2017, 9.52% in 2016 and 9.66% in 2015). At the county level, index for 2017

amounted to 97.85, meaning that the expenditures for employees in 2017 decreased by 2.15% in comparison with 2015. At the municipality level, the share of expenditures for employees is the most significant. In 2017, said share amounted to 10.7%, meaning that it decreased in comparison with 2015 (when it amounted to 11.48%) and in comparison with 2016 (when it amounted to 11.27%). Decrease in the share of expenditures for employees is also visible at the level of towns and municipalities combined, but also individually at the town level and individually at the municipality level. Calculated indices for 2017 indicate an increase, as well as calculated indices for 2016, with the exception of the expenditures pertaining to the municipalities. The absolute amount of total expenditures and expenses, as well as the absolute amount of expenditures for employees saw an increase, whereas the shares of expenditures for employees saw a decrease.

Table 4 Expenditures and expenses effected in all counties and the City of Zagreb, 2015 – 2017 according to the type of expenses and expenditures, relative figures, from Table 3

No.	Expenditures	% 2015	% 2016	% 2017	Index for 2015 = 100	
					Index for 2016	Index for 2017
1	Total all counties and City of Zagreb (20 counties + City of Zagreb)	100	100	100	105.47	110.01
1.1	Expenditures for employees (1.1./1.)	9.27	8.88	8.68	100.99	102.90
2	Total expenditures and expenses – COUNTIES (20 counties)	100	100	100	99.85	107.24
2.1	Expenditures for employees (2.1./2.)	9.66	9.52	8.81	99.48	97.85
3	Total expenditures and expenses - TOWNS AND MUNICIPALITIES (554 towns and municipalities)	100	100	100	106.59	110.56
3.1	Expenditures for employees (3.1./3.)	9.20	8.76	8.64	101.52	103.96
4	Total expenditures and expenses – TOWNS (126 towns)	100	100	100	107.34	110.90
4.1	Expenditures for employees (4.1./4.)	8.61	8.14	8.13	101.47	104.72
5	Total expenditures and expenses - MUNICIPALITIES (428 municipalities)	100	100	100	103.58	109.20
5.1	Expenditures for employees (5.1./5.)	11.48	11.27	10.70	101.69	101.70

Source: author, according to the data from Table 3



Source: author according to the data from Table 4, columns 3, 4 and 5, rows 1.1., 2.1., 3.1., 4.1. and 5.1.

Figure 1 Share of expenditures for employees in total expenditures at the level of all counties and the City of Zagreb, counties, towns and municipalities, cities and municipalities

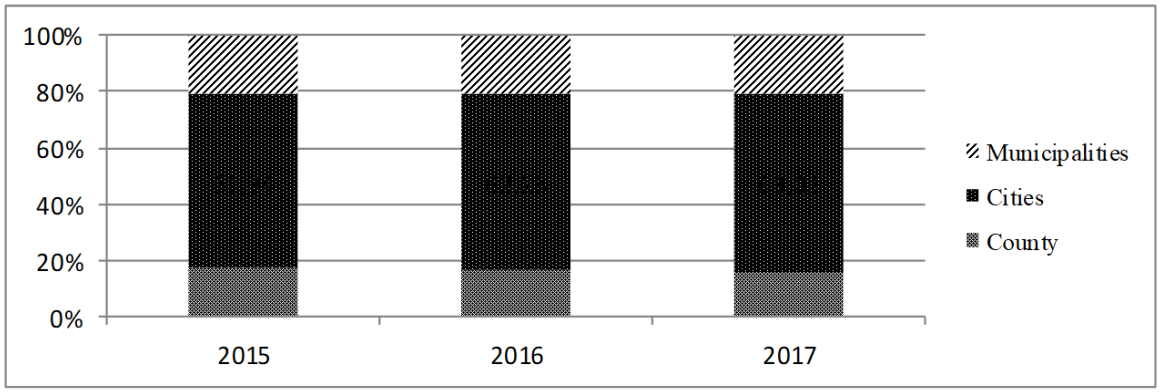
Figure 1 presents the share of expenditures for employees in total expenditures and expenses in 2015, 2016 and 2017, according to the data from Table 4. Share of expenditures for employees is presented at the level of all counties and the City of Zagreb, at the county level, at the level of towns and municipalities combined, individually at the town level and individually at the municipality level. In all observed years, the column representing the municipalities is the largest, meaning that the municipalities have the largest share of the aforementioned expenditures.

Table 5 presents an overview of expenditures for employees effected at the level of all counties and the City of Zagreb, at the county level, at the level of towns and municipalities combined, individually at the town level and individually at the municipality level. Table 5 also contains a calculation of the shares of expenditures for employees at individual levels of government and in total expenditures and expenses for employees (counties, towns and municipalities).

Table 5 Expenditures for employees by government levels

No.	Expenditures	2015	% 2015	2016	% 2016	2017	% 2017
1	Counties (20 counties)	363,945,830	17.25	358,431,056	16.82	356,109,348	16.40
2	Towns and municipalities (554 towns and municipalities)	1,745,661,498	82.75	1,772,258,674	83.18	1,814,747,478	83.59
3	Towns (126 towns)	1,306,697,863	61.94	1,325,881,471	62.23	1,368,326,993	63.03
4	Municipalities (428 municipalities)	438,963,635	20.81	446,377,203	20.95	446,420,485	20.56
TOTAL		2,109,607,328	100	2,130,689,730	100	2,170,856,826	100

Source: author according to the data of the Ministry of Finance



Source: author according to the data from Table 5, columns 4, 6 and 8

Figure 2 Expenditures for employees by government levels

Towns have the largest share in total effected expenditures for employees, followed by the municipalities and counties. This is also presented in Figure 2 for a better overview.

3.2. Expenditures for employees effected at the county level

Changes in effected expenditures for employees at the level of all counties and their share in total effected expenditures and expenses is presented below. Table 6 presents effected expenditures for employees in total expenditures and expenses effected at the county level in 2015, 2016 and 2017.

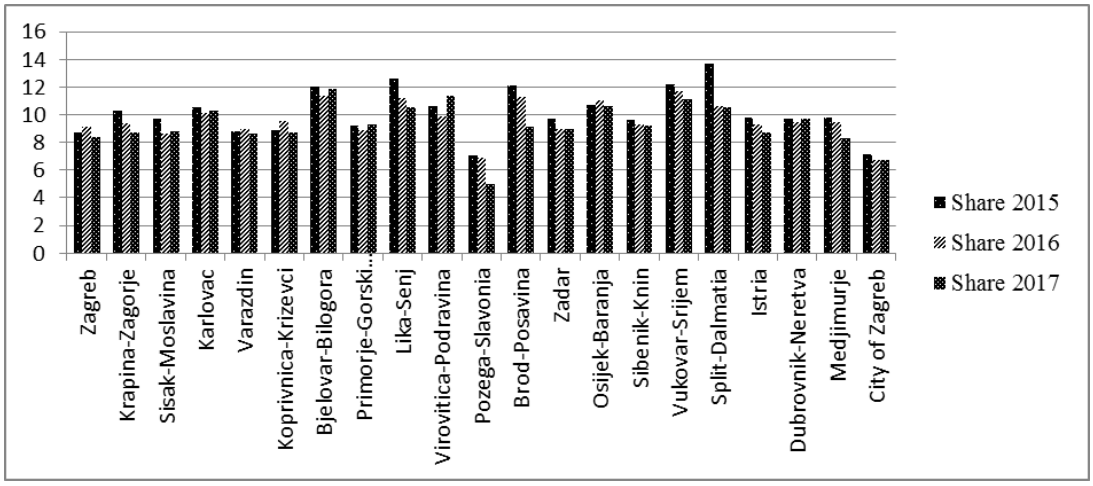
Data related to expenditures and expenses at the level of all counties includes expenditures and expenses of all municipalities, towns and counties.

Table 6 Share of expenditures for employees in total expenditures and expenditures by county

County	Expenditures for employees (in HRK)			Share in total expenditures of each county		
	2015	2016	2017	2015	2016	2017
Zagreb	125,714,684	130,846,778	129,614,011	8.68	9.14	8.37
Krapina-Zagorje	43,433,452	42,454,098	41,161,040	10.28	9.38	8.73
Sisak-Moslavina	70,824,771	69,928,757	69,537,900	9.68	8.61	8.80
Karlovac	55,550,905	56,920,625	57,503,483	10.53	10.14	10.25
Varaždin	57,999,824	59,888,808	59,938,474	8.77	8.93	8.65
Koprivnica-Križevci	44,348,069	48,301,813	44,888,715	8.89	9.54	8.70
Bjelovar-Bilogora	48,859,137	48,802,691	49,262,451	12.03	11.33	11.82
Primorje-Gorski Kotar	187,875,385	188,100,023	192,271,338	9.21	8.90	9.26
Lika-Senj	38,297,748	38,930,286	39,919,359	12.60	11.19	10.53
Virovitica-Podravina	38,297,430	34,875,185	38,576,537	10.63	9.86	11.37
Požega-Slavonia	5,817,346	5,538,477	5,595,565	7.09	6.91	4.98
Brod-Posavina	53,032,175	55,128,254	49,285,677	12.10	11.27	9.14
Zadar	94,406,755	93,355,476	95,617,934	9.71	9.00	8.95
Osijek-Baranja	125,787,186	122,141,473	129,946,657	10.71	11.04	10.59
Šibenik-Knin	54,015,363	51,773,867	55,880,316	9.62	9.33	9.21
Vukovar-Srijem	76,340,132	79,960,807	77,118,892	12.18	11.71	11.08
Split-Dalmatia	241,075,144	241,932,176	246,677,369	13.72	10.59	10.51
Istria	155,948,924	153,240,560	156,467,833	9.75	9.26	8.74
Dubrovnik-Neretva	81,871,886	82,107,725	85,059,468	9.67	9.44	9.70
Međimurje	37,330,157	40,523,185	37,837,497	9.76	9.49	8.26
City of Zagreb	455,008,427	466,015,518	490,178,772	7.14	6.72	6.69
TOTAL	2,109,607,328	2,130,689,730	2,170,856,826	9.27	8.88	8.67

Source: author according to the Ministry of Finance

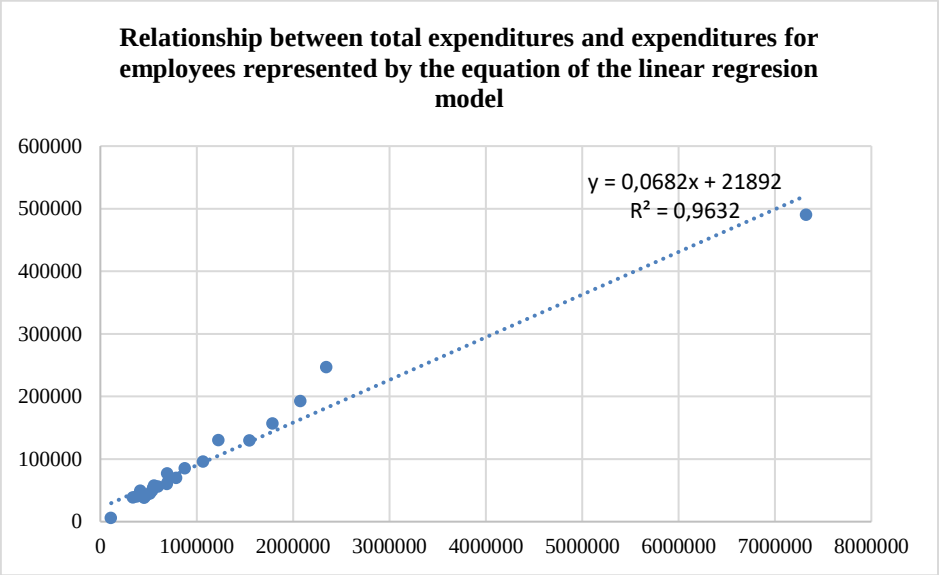
Said changes are listed in Table 6 and they are also presented in Figure 3 for a better overview. The average share of expenditures for employees in total expenditures and expenses at the level of all counties, excluding the City of Zagreb, amounted to 16.52% in 2004 and 16.03% in 2005 (Mahaček, 2007, p. 582). According to the data from Table 6, the share of expenditures for employees in total expenditures and expenses at the level of all counties and the City of Zagreb amounted to 9.27% in 2015, 8.88% in 2016 and 8.67% in 2017. We conducted a regression analysis by assigning an independent variable (x), total expenditures and expenditures in 2017 by counties.



Source: author according to the data from Table 6, columns 5, 6 and 7

Figure 3 Share of expenditures for employees in total expenditures

For the dependent variables (y), we took the expense for the employees by counties in 2017. Using the statistical analysis by MS Excel (Papić, 2005, pp. 145-150), we obtained the equation of the linear regression model and the result was graphically presented (Figure 4).



Source: author's calculation

Figure 4 Correlation of expenditures for employees and total expenditures

Figure 4 confirms positive and high correlation between the two phenomena. The uniform growth in total expenditures is accompanied by a steady growth in employee expense, which is also confirmed by the regressive coefficient b, which is positive.

3.3 Audit procedures for expenditures for employees

Audit of expenditures for employees is an integral part of the audit procedure for expenditures and expenses of local units, as well as of any entities performing a financial audit. Audit of expenditures and expenses must determine total effected expenditures and expenses in relation to planned expenditures and expenses, as well as in relation to the previous year. Also, it must determine the reasons for any material departures (Mahaček, 2016).

We get the information from the financial statements. The users of the financial statements are numerous, from the state, business partners and all the public. Especially when it comes to budget allocation. "In addition, it is necessary to point out that the financial statements are public documents and that market economies imply the freedom of disposal of information contained in the financial statements" (Tušek, Žager, 2006, p. 52).

In the audit procedure, it is necessary to determine the number of employees in local and regional self-government units and the number of employees of budget beneficiaries. The fundamental act governing salaries is the Act on Salaries in Local and Regional Self-Government Units (Official Gazette 28/10).

This Act prescribes the standards for determining salaries and benefits of county prefects, town mayors and municipal mayors and their deputies, as well as the salaries of officials and other employees at administrative departments and services of local and regional self-government units. General documents governing payment of salaries must comply with legal provisions. Payment of salaries in local units is performed under a decision on salaries. At the town level, this is a decision of the town council on salaries of town employees. At the level of municipalities, such decisions are adopted by the municipal council.

Objectives of auditing expenditures for salaries and liabilities for salaries require that the following be verified:

- Existence Payroll expense is a valid expense and related accruals are valid liabilities.
- Completeness: All payroll expense and related accruals have been recorded.
- Cutoff: Payroll expense and related accruals are recorded in the correct accounting period.
- Rights and obligations: All disclosed matters relating to payroll expense and related accruals have occurred and pertain to the entity.
- Accuracy: Payroll expense has been properly accumulated from journals and ledgers.
- Valuation Payroll expense and related accruals are valued in accordance with auditing standards.
- Classification: Payroll expense and related accruals are properly classified in financial statements.
- Disclosure: All disclosures relating to payroll expense and related accruals that should have been included in the financial statements have been included." (Messier Jr.,1998, p. 498).

Budget-based limitations on salaries have been determined in the Act on Salaries in Local and Regional Self-Government Units (Official Gazette 28/10). It has been determined that the budget-allocated funds for salaries of employees of a local or regional self-government unit cannot exceed 20% of the unit's operating revenue realised in the previous year less various aids, revenue realised on the basis of special agreements and aids from the state budget.

4 Discussion

Effecting of expenditures for employees in each local unit is an issue of great importance. Local units - municipalities, towns and counties - are numerous. In their internal documents, local units define the framework according to which employees' salaries are calculated and paid. In doing so, it is necessary to comply with legal provisions, which have limited the amount of budget-allocated funds for salaries in relation to budgetary revenues realised by local units and the amount of salaries. In case of higher budgetary revenues that do not pertain to state aids and assigned revenue (the allocation of which is prescribed by the law), employees' salaries can be higher as well. Local units use realised revenue to finance public needs. For that reason, the amount of expenditures for employees represents an important issue. Firstly, budget funds must be used to ensure proper functioning and fulfilment of requirements falling under the competence of local units. Local units should first justify the purpose of their existence and only then ensure salaries for their employees. Also, many other issues arise from the fact that the number of municipalities is large. Smaller municipalities have fewer employees, but the scope of their business operations is equal to that of larger units. Therefore, employees are required to be competent for performing multiple tasks. Salaries are limited, meaning that it is not possible to receive higher salaries for performing more tasks. It is necessary to research whether there are possibilities for increasing budgetary revenues, in particular revenues of municipalities, to make their role in financing and fulfilling public needs more prominent. Only then will it be justified to increase the employees' salaries.

Conclusion

The paper contains a study of expenditures for employees in relation to their amounts and share in total expenditures and expenses and changes in their absolute and relative amounts. The assumption that the share of expenditures for employees at the level of individual local units varies and that said share is significant has been confirmed. The share of expenditures for employees in total effected expenditures and expenses has decreased, probably as a consequence of achieving compliance with legal provisions related to the limitations of salaries. Expenditures for employees at the municipality level have the most significant share in total effected expenditures and expenses of all local units. Nowadays, smaller local units also have fewer employees and their competence is prescribed by the law, which is why the employees must fulfil the requirement of performing multiple tasks they are assigned. Therefore, in relation to expenditures for employees and the necessity of ensuring funds for larger investments, other issues crucial for proper and efficient functioning of local units arise as well. The shares of effected expenditures for employees at the level of individual counties indicate that said expenditures are significant and that the share of individual counties in said expenditures varies. It can be concluded that the larger the share of expenditures for employees in total expenditures and expenses, the lower the amount of funds available to local units for financing other expenditures. Expenditures for employees are recorded within operating expenditures. Based on the conducted research of the amount of effected expenditures and expenses at the county level, it is visible that operating expenditures account for the most significant share in total effected expenditures and expenses, i.e. that a smaller portion of budget funds can be spent on expenditures for acquisition of non-financial assets, expenditures for financial assets and loan repayments. This paper examines the amount of and changes in expenditures for employees in local units and the correlation between employee expenditures and total expenditures. Future research should focus on the number of employees in local units. The area of expenditures for employees remains significant and it should be examined further to find the potential for a more useful and simpler use of the money from the state. This would be beneficial since municipalities are the most numerous of all local units and since their scope of activities includes a wide range of business operations, which require an adequate number of employees. To encourage economic development, it is necessary to make investments for which smaller local and regional units lack sufficient funds.

References

ČULO, I. (2011). *Funkcioniranje lokalne i područne samouprave u Republici Hrvatskoj*. Geno d.o.o. Požega, ISBN 978-953-95273-5-6

MAHAČEK, D. (2007). Implemented expenditures and outlays of local and regional self-government units in the Republic of Croatia with special emphasis on the audit of staff expenditures. Chapter 51 in DAAAM International Scientific Book 2007, B. Katalinic (Ed.). Vienna, Austria Doi 10.2507/daaam.scibook.2007.51

MAHAČEK, D. (2016). *Revizija u zdravstvenome sustavu*, Faculty of Medicine in Osijek, ISBN 978-953-7736-28-6

PAPIĆ, M. (2005). *Primijenjena statistika u MS Excelu*. Zoro d.o.o. Zagreb, ISBN 953-6296-47-0

TUŠEK, B., ŽAGER, L. (2006). *Revizija, Hrvatska zajednica računovođa i financijskih djelatnika*. Zagreb

WILLIAM F. MESSIER JR. (1998) *Revizija – Priručnik za revizore i studente*. Faber & Zgombić Plus, Zagreb

HRVATSKI SABOR: *Zakon o lokalnoj i područnoj (regionalnoj) samoupravi*, Official Gazette 33/01, 60/01, 129/05, 109/07, 125/08, 36/09, 150/11, 144/12, 19/13, 137/15 and 123/17

HRVATSKI SABOR. *Zakon o područjima županija, gradova i općina u Republici Hrvatskoj*, Official Gazette 86/06

HRVATSKI SABOR. *Zakon o plaćama u lokalnoj i područnoj (regionalnoj) samoupravi*, Official Gazette 28/10

REPUBLIKA HRVATSKA, MINISTARSTVO FINANCIJA. (2018). *Ostvarenje proračuna JLP(R)S za period 2014–2017*. Retrieved from http://www.mfin.hr/hr/ostvarenje-proracuna-jlprs-za-period-2014-2017

REPUBLIKA HRVATSKA, MINISTARSTVA FINANCIJA. *Pravilnik o proračunskom računovodstvu i Računskom planu*, Official Gazette 124/14, 115/15, 87/16 i 3/18

Innovation Scorecard in an Agile Software Development Working Environment

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Abstract

Purpose of the article The paper provides a literature analysis of relationships between agile management methods and innovation management control. It considers a potential implementation of an Innovation Scorecard framework within software development organisations.

Methodology/methods The theoretical background is based on a methodical system approach: analysis, comparison and synthesis. Analysis is used to acquire new knowledge and its interpretation. When processing secondary data, the secondary analysis method was used. Professional literature, particularly foreign sources, provided a source of secondary data. Synthesis was used designing an Innovation Scorecard solution within a short term project that was based on a Scrum approach.

Scientific aim The scientific aim of the paper is to gain knowledge and analyze the present status of agile management and innovation management control as it pertains to the Czech and foreign professional literature. The objective of the article rests in the summary and presentation of results of a literature analysis of the relationship between those areas. In addition, the paper is also important in terms of innovation management, which is a field of science, and also of related disciplines, specifically strategic management.

Findings On the basis of the literature review, the process for the design and implementation of an Innovation Scorecard within an IT organization is proposed. The Innovation Scorecard methodology does not represent a static framework but can be customized according to the specific needs of an individual innovation project. When applied in Agile environments measuring gates (check-points) can be removed to fit in with that particular environment.

Conclusions The authors present the potential benefits of the Innovation Scorecard implementation. They are aware of limitations which lead to opportunities in any future research. These shortfalls will be recovered in a planned followed-up project known as 'Innovation Scorecard: Management Control Framework of Innovation Project in IT industry' no. TL02000007. This is supported through funding from the Program Éta by the Technology Agency of the Czech Republic.

Keywords: innovation, agile software, Scrum, innovation scorecard, KPIs, metrics, process efficiency

JEL Classification: M15, M21

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Introduction

The application of agile management methods within software development work environments is a topic of regular discussion. In general, agile methods have been created for application in small software development projects (Boehm and Turner, 2005). Their application in large projects is challenging, particularly in areas of planning and coordination (Dybå and Dingsøyr, 2009). There are other characteristics associated with this approach such as fast decision making, incremental working, flexible development and autonomous working practices (Austin and Devin, 2009). Drucker (2009) considers that "If you can't measure it, you can't manage or improve it". This raises the question whether it can be justified to introduce a measurement system into an innovative or Agile working environment. Many authors of related literature suggest that this is probably true to say for both areas. Efficient and user-friendly measurement systems are essential and crucial to the success of innovation work or project approached. As a result, some authors considered it important to combine the concepts of Innovation Scorecard and Agile Methodology. Agile is based on a flexible approach, is dynamic and provides fast access to solutions within software development environments. The primary advantage is its flexibility and ability to react quickly and flexibly to changes/changing work environments. The Innovation Scorecard concept works on some logical step by step process of implementation within organisations (Žižlavský, 2016).

The scientific aim of this paper is to gain knowledge and overview of recent trends in Agile management and innovation management control. It is dedicated to a potential implementation of an innovation management control framework called Innovation Scorecard within the area of process innovation within a well-established global IT organisation in Brno. It is meant to serve as an inspiration for organisations that apply Agile methods and who seek an Innovative Scorecard solution. These organisations typically operate in work environments that are at the cross-road to review their current internal processes so they can improve how they work and operate within Agile working practices including strategy management.

The paper is based on a literature review of existing Agile and Innovation Scorecard methods. System approach, analysis, comparison and synthesis (Hendl, 2012) are applied in this paper. Analysis is used as a method of acquiring new knowledge and the interpretation of that knowledge. When processing secondary data, the secondary analysis method was used. The professional literature, and particularly foreign sources, provided a source of secondary data. Synthesis is used for the Innovation Scorecard design within a short project that engages the well-known project management method of SCRUM. The first part of the paper reviews a number of definitions of what is meant by Innovation. The next section presents the Innovation Scorecard background. The third section is dedicated to the Agile methodology with its primary focus on SCRUM. Finally, the last section discusses the implementation of an Innovation Scorecard system within an Innovation Project that employs the SCRUM approach. Application limitations are presented in the Conclusion section.

1 Definition of Innovation

A review of the current literature revealed that the term innovation is interpreted in many different ways and that it is subject to numerous classifications, typologies and categorisations, such as Birkinshaw et al., 2008; Fagerberg et al., 2005; Maital and Seshadri, 2007; Meeus and Edquist, 2006. It appears that disorder and chaos is revealed in some literature as far as the meaning and interpretation of innovation is concerned (Davila et al., 2009; Gailly, 2011; Yusof et al., 2010). Historically research on the classification of innovations concentrated on the technological imperative of innovation, assuming that companies carry out innovative activities through research and development (R&D). Several studies on and definitions of innovation have been produced, pertaining directly to R&D such as Gallouj and Weinstein, 1997; Mairesse and Mohnen, 2004 and Miles, 2001. According to some definitions the main characteristics of innovations are change and considerable novelty (Gault, 2013; OECD, 2005, Valenta, 1969). Another widely used concept defines innovation as a tool for creation of new knowledge (Senge, 2005). The Oslo Manual (OECD, 2005) provides a clear definition of the term innovation and this helps to demystify what is meant by innovation. It is the foremost international source of guidelines for the collection and use of data on the concept of innovation. It was prepared by experts in the field of measurement and evaluation of innovation from OECD member states. According to the more recent, broader approach of the Oslo Manual, four main types of innovation are recognised:

- Product innovation
- Process innovation
- Marketing innovation

- • Organisational innovation (OECD, 2005).

2 Innovation Scorecard

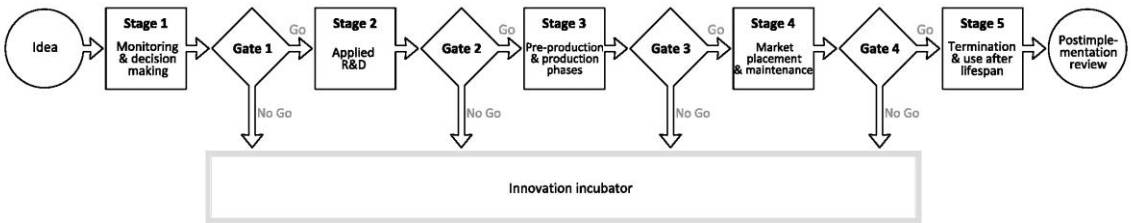
The Innovation Scorecard model was developed by Žižlavský (2016) for application within companies in the Czech Republic. His framework builds on the work of Kerssens van Drongelen et al. (2000) and also Pearson et al. (2000) by introducing already known and considered popular management techniques and methods (Table 1).

Table 1 Innovation Scorecard Background

Method	What (Author)
Balanced Scorecard	Balance between financial/non-financial metrics, short/long-term goals (Kaplan and Norton, 1996)
	Sequence "Aim–Cause&effect–Metric–Target Value" (Horváth, 2002)
	Scorecard design (Niven, 2014)
	Number of metrics (Kaplan and Norton, 1996)
	Casual links – strategy maps (Cokins, 2009)
Innovation	Innovation pipeline (e.g. Bessant and Tidd, 2011; Davila et al., 2013)
	Input–Process–Output–Outcome Model (Brown, 1996)
	Stage Gate Model (Cooper, 1998; 2008)
	Open inovace (Chesbrough, 2003)
Project management	Wingate (2015)
KPI design	Niven (2014), Parmenter (2015)

Source: Žižlavský, 2016

The theoretical background, structure (including processes) and methodology of the suggested Innovation Scorecard can be divided into a number of distinct stages including some management decision gates to aid control. The suggested Innovation Scorecard approach incorporates the core functions of leading innovative teams such as defining tasks, planning, controlling, evaluating/reviewing and supporting. This effective and efficient approach to introduce the concept of Innovation Scorecard into organisations is vital for moving innovations from the idea to launch phase in a systematic, managed and controlled way. The proposed Innovation Scorecard (Figure 1) suggests six distinct stages controlled by gates where Go/No Go decisions are made whether to proceed to the next gate: Gate 0 Concept/Idea; Gate 1 Feasibility; Gate 2 Planning; Gate 3 Implementation; Gate 4 Verification (including pilot studies/testing); Gate 5 Deployment (Roll-out or Going Live); Gate 6 Closed Down (Post Implementation Review including Lessons Learned/Knowledge Management).



Source: Žižlavský, 2016

Figure 1 Innovation Scorecard Framework

2.1 System Design

It appears that an innovation system is considered to be able to measure anything that can be measured and that the process should be applied continuously. Measurement forms an integral and essential part of innovation and is very important for the success of the innovation process (Davila et al., 2013). When organisations decide to apply

the innovation scorecard, they expect results commensurate with effective decision making. Expected outcomes of its application should be economic and add value to the effective running of organisations. It is suggested that a reasonable complex and sufficiently developed innovation scorecard system should be deployed to achieve maximum benefit (Horváth and Partners, 2002).

Keegan et al. claim that there are three main steps in a typical measurement system. The first step is to define the strategy and associated goals of the company. The second is to develop a set of performance measures and the third goal is to focus on linking the performance management system to management thinking and expectations (Keegan et al., 1989). The essential structure of an Innovation Scorecard derives from the long-term experience of the process of implementing a Balanced Scorecard within a company (Horváth and Partners, 2002). The structure has to be developed in such a way as to guarantee the effectiveness of the Innovation Scorecard (Žižlavský, 2016).

Source: adapted from Horváth and Partners, 2002; Cokins, 2009

Figure 2 Innovation Scorecard Process

The long-term structure of an Innovation Scorecard is based on the implementation of the Balanced Scorecard from which it originates. This process involves 7 phases which provides details of the approach taken to implement the Innovation Scorecard within a company. The innovation strategy needs to be defined at the beginning and needs to contain a strategic plan, the goals of any project and how to achieve these. These need to be agreed and approved by senior management. The set goals have a direct impact on the successful implementation of the Innovation Scorecard. In addition, relevant and appropriate Critical Success Factors (CSFs) are developed based on the set goals. These are high level goals that focus on what needs to be done (and not the how). At the level below CSFs, Key Performance Indicators (KPIs) are created and their task is to inform how the company will deliver the CSFs (the how). An innovation map can help any company how to implement and apply the CSF/KPI strategy in practice. Effective communication forms a very important element of the innovation scorecard process. Those involved in developing and implementing the process need to communicate and be communicated to regularly to keep everyone informed of progress. Metrics need to be developed and rolled out and managed. They form an essential part of any innovation scorecard process. Goals should be SMART (specific, measurable, attainable, relevant and time-based). Goals need to be considered and prepared at the start of any project and their details are often presented and agreed during a project definition workshop (PDW) that is usually run at the end of the feasibility phase of a project. Goals must have target performance values and these values must be realistic to achieve (Žižlavský, 2016).

2.2 Key Performance Indicators (KPI)

KPIs measure performance, both present and future. They are specific and detailed performance measurements that will allow companies to ensure that they achieve their set performance goals and targets. They are expressed in numerical and/or % form and should be sufficiently specific in detail such as 'We will grow our customer base by 20% by 31 December 2019 by cold-calling 50 customers each month'. KPIs underpin the higher-level CSFs. KPIs can be expressed in financial terms, too, such as Return on Investment (ROI) or Internal Rate of Return (IRR). KPIs are typically measured monthly but this depends on the complexity, for example, of any project. In some instance they may need to be measured more frequently. This needs to be decided by any project manager or senior management team at the beginning of any work initiative. In addition, individuals and teams need to understand their role and responsibility to deliver KPIs successfully. KPIs are usually the responsibility of the project manager but can also be owned by CEOs of smaller companies. KPIs have a significant impact on the organisation (Parmenter, 2015). Positive KPI outcomes are a sign of success and negative KPI outcomes are a sign of failure. Regular reviews provide opportunities to identify negative KPIs and turn these around to become positive KPIs. It should also be noted that not all KPIs are automatically metrics. KPIs are very specific performance indicator and metric focus more the general performance. Both KPIs and metrics can be used in parallel as they often complement each other. This needs to be managed carefully (Kerzner, 2017). This performance measurement system forms part of any innovation scorecard system. This composition is defined by a number of authors such as Neely et al (1996) who consider this system as being a process of the effectiveness of

associated actions. The management of the system is defined as a process of managing performance, strategies and objectives (Lehner, 2016). A performance measure is defined as a metric which is used to ascertain any effectiveness of actions (Neely et al., 1996).

2.3 Metrics

Metrics are a tool used to measure, for example, innovation processes in organisations. In addition, they can be applied to identify or predict potential areas that would benefit from innovation. This includes the definition of the strategy and describes the steps that need to be taken to achieve this. It is often applied to clarify and translate the organisation's vision. One approach is to identify and visualize strategic objectives and produce a so-called strategy map. The strategic objectives and measures can then be linked and appropriate KPIs can now be assigned to the strategy map. This includes the setting of targets for each of the KPIs. It is a necessary requirement for the successful application of an innovation scorecard system to support the control process of implementing an innovation strategy and the impact this has on the organization. Following this process will provide learning opportunities and identify more opportunities for new and future application of KPIs and metrics (Trias de Bes and Kotler, 2011). A sample of metrics divided into various groups can be found at Table 2.

Table 2 Metrics for Innovation – Examples

Metrics	Example
Number of innovations realised	Garcia and Calantone (2002)
	Verbeek et al. (2002)
Bibliometric Indicators	Number of publications (such as books and papers in respected scientific journals)
Number of registered patents	Pharmaceutical Industry: 1 or 2 patents per year (Chiesa and Frattini, 2009)
Expense on R&D	OECD (2009)
	Return on Product/Service Development Expenses (Malinoski and Perry, 2011)
Financial indicators	Thomaschewski and Tarlatt (2010):
	Growth of competitiveness and financial health
	Profit
	Financial impact of Innovation
	Methods for the evaluation of innovation efficiency (Gailly, 2011)
Non-financial indicators	Internal process (Bessant and Tidd, 2011):
	Number of new Ideas
	Extent of Failure
	Number/percentage ratio of exceeding development time and budget (cost)
	Customer satisfaction criteria
	New Product Development implementation time

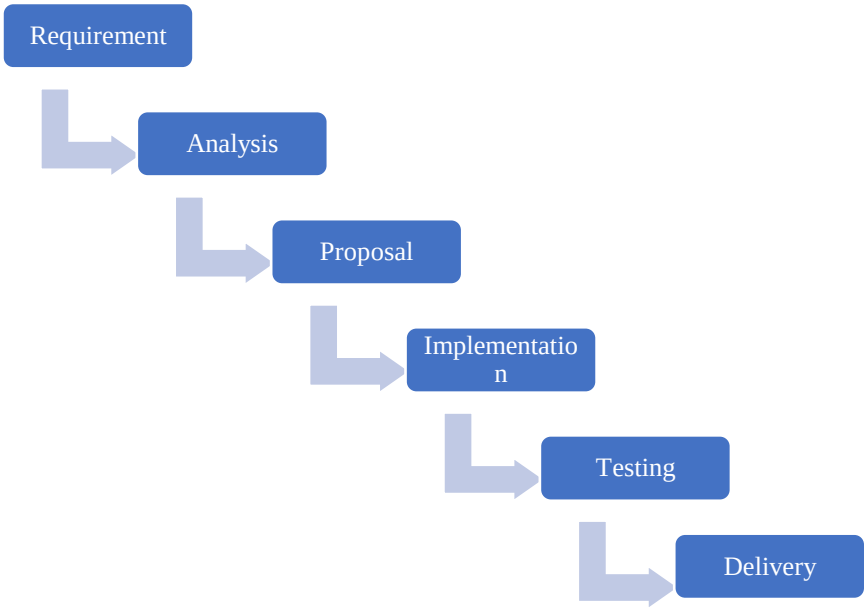
Source: Žižlavský, 2016

The Innovation Scorecard concept is typically applied to cover both financial and non-financial aspects of measuring improvements with the aim to achieve a realistic balance between the two. The importance of financial metrics is reflected in the value they add to the decision-making process within organisations. This is essential for proving that the organisation has been successful in achieving their set target performance levels. Performance metrics provide a means to ensure that set goals or objectives have been achieved. Goals and objectives are usually agreed at the beginning of any innovation process. These are included in so-called project definition documents (PDD) and need to be managed to their successful conclusion by the person in charge of the project, typically a project manager. In Agile projects, historical data can be used to aid short term deliveries of software development innovations and upgrades/updates (Kislingerová, 2008). Non-financial metrics include the effective measurement of how deployed resources are performing and to ensure that innovation goals are achieved effectively and efficiently. These metrics are sensitive to change and need to manage accordingly. They form part of internal

processes at both organisational and work package delivery level. They assist in long term decision making and as such are suitable for longer work life cycles (Bremser and Barsky, 2004).

3 Agile Methodology

Agile software development is an umbrella term for a set of frameworks and practices based on the values and principles expressed in the Manifesto for Agile Software Development and the twelve principles behind it (Agile Alliance, 2019). When software development is approached in a particular manner, it is generally advisable to follow these values and principles and to use them to work out the right things to do in particular contexts. One thing that separates Agile from other approaches to software development is the focus on how people work and how they co-operate with each other. Solutions evolve through collaboration between self-organising cross-functional teams using appropriate practices for their context. Agile was developed by a group of software developers in 2001 and is used extensively within the IT industry. In general terms, the Agile approach or methodology has a number of intrinsic values (Fowler and Highsmith, 2001). Being able to respond in a dynamic way without unnecessary bureaucracy or other hindrance is paramount, for example, to software development project work. A system that is fast and flexible at the same time and a system that can respond to changes swiftly adds value to users of an Agile approach. Focusing on results rather than adherieng to a rigid and strict process is of paramount importance to the successful delivery of so-called Agile projects or work. This requires that those involved in Agile working, should have an Agile mindset that is reflected in their Agile behaviours. For this work well and effectively, this needs to be achieved at individual, team and corporate levels and applied consistently across the organisation. According to Šochová and Kunce (2014), communication plays an important role within an Agile work environment. It does and should not replace following necessary processes but it aids consistent understanding of what needs to be done, by when, how and by whom. Good communications complement frequent request for changes well and efficiently. One of the early models that was used in the area of software development is generally known as 'Waterfall' (Fig.3). Its design dates back to the early 1950s and in essence it focuses on sequential task completion. Ashmore and Ruuyan (2014) suggest that this approach does not contain any flexibility for stepping outside the sequential process. It appears that Waterfall is a popular linear and sequential process that contains a number of distinct phases. It is generally not possible to return to a previous phase so any newly-adopted changes cannot be applied retrospectively. This may affect long term projects where changes appear to be 'the order of the day' and where a certain amount of flexibility can reasonably be expected. McConnell (2004) reports that this could affect software development projects: changes in requirements during project execution and delivery, when not integrated into the design, will affect the end product/service in terms of customer expectation.



Source: Myslín, 2016

Figure 3 The Waterfall Process

According to Selectbs.com (2019), Extreme Programming (XP) is a software engineering methodology that forms part of a group of several agile software development methodologies. It differentiates itself from other agile methodologies by placing much higher values on adaptability rather than predictability. Proponents of XP regard ongoing changes to requirements as an often natural and often inescapable aspect of software development projects; they believe that being able to adapt to changing requirements at any point during the project life is a more realistic and better approach than attempting to define all requirements at the beginning of a project and then expending effort to control changes to the requirements. XP prescribes a set of day-to-day practices for managers and developers; the practices are meant to embody and encourage particular values. Proponents believe that the exercise of these practices—which are traditional software engineering practices taken to so-called "extreme" levels—leads to a development process that is more responsive to customer needs ("agile") than traditional methods, while creating software of similar or better quality. Generally, Extrem Programming initially recognized and accepted four values, with a fifth value being added more recently. The five values are:

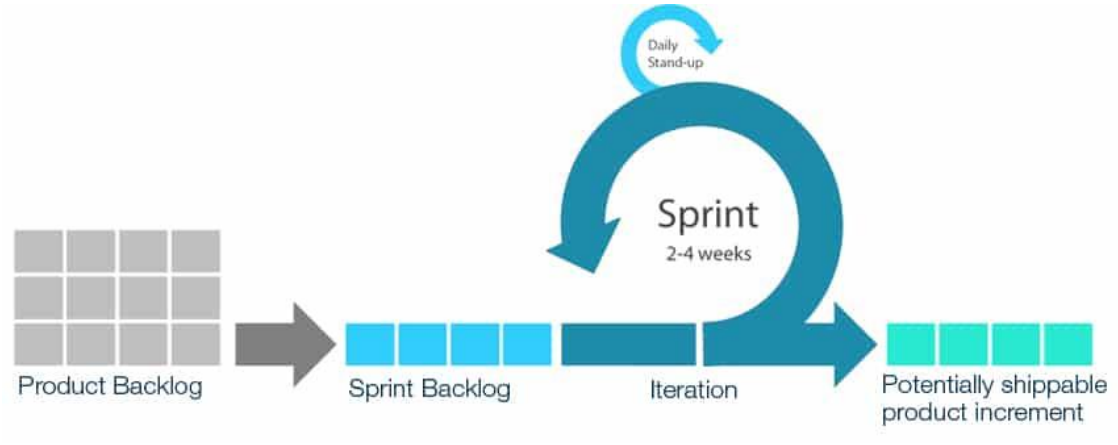
- Communication
- Simplicity
- Feedback
- Courage
- Respect

In addition, some other software development processes are used such as Feature-Driven Development. This is an iterative software development process. It is a lightweight or Agile method for developing software. FDD combines a number of industry-recognised best practices into a cohesive whole. These practices are driven from a client-valued functionality perspective. Further methods include Lean Software Development, Kanban Method, Dynamic Systems Development Method and Crystal Family.

3.1 Scrum

According to Versionone.com (2019), Scrum, for example, in software development work environments, is a methodology for managing software delivery that comes under the broader umbrella of agile project management (Fig.4). It provides a lightweight process framework that embraces interative and incremental practices, helping organisations deliver working software much faster and more frequently. The series of iterations are known as ‘Sprints’ (typically lasting four weeks and driven by goals set at the beginning of each sprint) and at the end of each sprint the team produces a potentially deliverable product increment. This approach differs from the Waterfall approach that fixes the project scope upfront, requiring the extensive creation of requirements, analysis and design documentation before development can get started. It appears that there is a difference of opinion regarding the origin of Scrum.

Some professionals believe that Jeff Sutherland, John Scumniotales and Jeff McKenna invented Scrum in 1993, others believe that Hirotaka Takeuchi and Ikujiro Nonaka invented Scrum in 1986. The Scrum approach benefits from the advantage that any changes can be accepted and integrated into the design work immediately and without undue delay. This includes, for example, the integration of constant customer requirements changes and the ability to manage these instantly. Typical Scrum activities are: Sprint Planning Meeting, Daily Scrum or daily Stand-up, Sprint Review and Sprint Retrospective. In terms of Scrum Team roles, a typical Scrum team needs three specific roles: product owner, Scrum master and the development team (Agile42.com, 2019). Scrum teams are cross-functional and this is the reason why the development team includes testers, designers, so-called UX specialists and operational engineers in addition to developers.



Source: nutcache, 2018

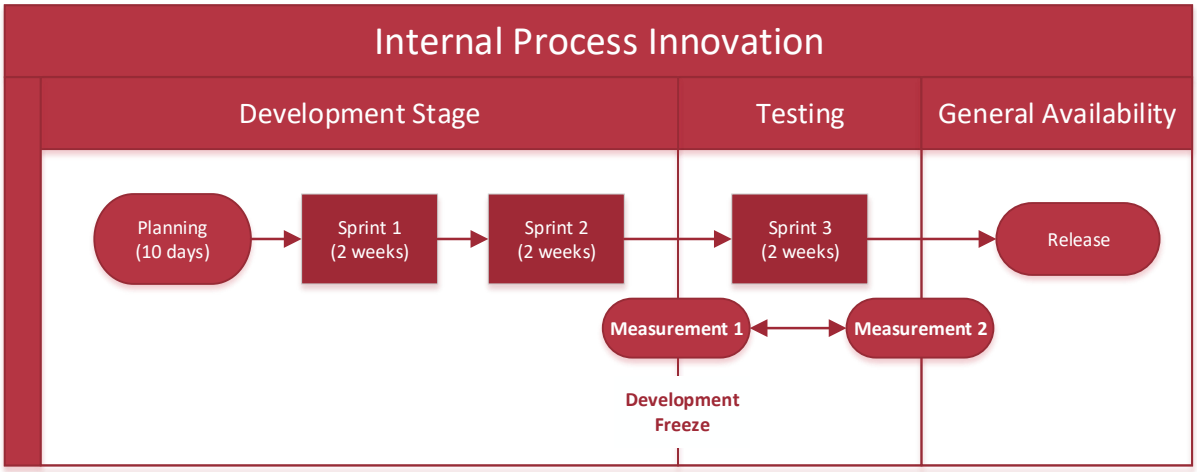
Figure 4 Scrum Sprint Process

4 Discussion

Based on the outcomes of a literature review, the considered and suggested process for the design and implementation of an Innovation Scorecard system for IT/Software Development organisations is:

- Innovation Scorecard objectives and goals are defined and agreed at the start of any initiative such as a project. This includes aligning these to the current organisation's strategy/strategic map.
- Innovation Scorecard metrics for each decision-making gate are developed/agreed and realistic target measurement values are established/agreed.
- Agreed metrics will be catalogued and entered into an Innovation Scorecard Control Data Sheet.

The Innovation Scorecard methodology, developed and established by the Innovation Scorecard team in Brno (Pavla, Ondrej and Eddie) will be updated and made 'fit for intended purpose' to meet the needs and requirements of individual organisations. Fig. 5 shows a summary of the developed Innovation Scorecard Sprint.



Source: own processing

Figure 5 Innovation Scorecard Sprint

As the innovation project is in the area of software development (including short sprints), the authors consider that the application of a 'gate process' to manage each small project is not justified as it does not add any value to the overall process. The internal process where Innovations Scorecard is going to be implemented consists of 3 sprints: 2 development and 1 testing. Any future research project will focus on process innovation in the area of test sprint. The efficiency of any process innovation will be measured at the end of each test sprint such as each 2-week period. The collected data will be compared with stated/set goals (target value) and default state (state before the launching of any process innovation) in order to identify and report any target trends such as to minimize or maximize). Inputs lead to outputs. Processes are used to get from input to output.

The purpose of the Innovation Scorecard initiative is not to improve IT organisation's current quality management system. Such a system already includes all necessary processes. The goal/purpose of the introduction of an Innovation Scorecard system is to improve the management of inputs and outputs through innovative approaches to improve areas such as job satisfaction, staff motivation and morale, customer perception and associated outcomes such as improving productivity, reduce business overheads and generate new/repeat business for chosen IT organization. In addition, the number of applied metrics needs to be reduced.

Despite Kaplan and Norton (1996) stating 'twenty is plenty', the authors consider that this number of metrics would create additional unfavourable bureaucracy. It is considered that approximately 5-10 metrics is a sufficiently large number to be able to measure the efficiency of a 2-week sprint. The quality of these metrics and their overall contribution to the successful introduction of an Innovation Scorecard system are of paramount importance.

Conclusion

This paper draws upon what is already known about management control system design, agile methods in software development and the concept of an Innovation Scorecard framework. From a managerial viewpoint the Innovation Scorecard may provide useful guidelines for focusing attention and expending resources during the entire innovation process. The following benefits can be expected after the successful introduction and roll-out of an Innovation Scorecard system:

- Higher profitability from a market and product perspective.
- Improved Return on Investment (ROI).
- Higher staff productivity levels through business change including improved organisational alignment and modus operandi.
- Improved streamlining of software development processes through the roll-out of an Innovation Scorecard System across a number of associated projects.
- Improved timely internal and external communications.

The authors are aware of a number of limitations that need to be addressed in future research. The most significant is that this study is grounded based on a theoretical secondary data analysis. The practical application of an Innovation Scorecard framework in real projects within the IT industry will be conducted. This considered project has a life span of three year and will be known as the 'Innovation Scorecard: Management Control Framework of Innovation Project in IT industry' no. TL02000007, supported through funding from 'Program Éta' (Technology Agency of the Czech Republic).

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References

AGILE42. (2019). *Are you ready for the Agile change?* Retrieved from: www.agile42.com

AUSTIN, R. D., DEVIN, L. (2009). Research commentary-weighing the benefits and costs of flexibility In making software: toward a contingency theory of the determinants of development process design. *Information Systems Research*, 20(3), 462-477.

ASHMORE, S., RUNYAN, K. (2014). *Introduction to Agile Methods*. Addison-Wesley Professional.

BESSANT, J., TIDD, J. (2011). *Innovation and entrepreneurship*. Hoboken, New Jersey: John Wiley & Sons.

BIRKINSHAW, J., HAMEL, G., MOL, M. (2008). Management innovation. *Academy of Management Review*, 33(4), 825-845. ISSN 0363-7425.

BOEHM, B., TURNER, R. (2005). Management challenges to implementing agile processes in traditional development organizations. *IEEE Software*, 22(5), 30-39.

BREMSER, W.G., BARSKY, N. P. (2004). Utilizing the balanced scorecard for R&D performance measurement. *R & D Management*, 34(3). ISSN 1467-9310.

BROWN, M. G. (1996). *Keeping Score: Using the Right Metrics to Drive World Class Performance*. New York, NY: Productivity Press.

COKINS, G. (2009). *Performance management: integrating strategy execution, methodologies, risk, and analytics*. Hoboken, New Jersey: John Wiley & Sons.

COLLABNET | VERSIONONE. (2019). *Scrumworks pro*. .Retrieved from: www.versionone.com

COOPER, J. R. (1998). A multidimensional approach to the adoption of innovation. *Management Decision*, 36(8), 493-502. ISSN 0025-1747.

COOPER, R.G. (2008). Perspective: The Stage-Gate idea-to-launch process - update, What's new and Next Gen Systems. *Journal of Product Innovation Management*, 25, 213-232. ISSN 1540-5885.

DAVILA, A., FOSTER, G., LI, M. (2009). Reasons for management control systems adoption: Insights from product development systems choice by early-stage entrepreneurial companies. *Accounting, Organizations and Society*, 34(3-4), 233-347. ISSN 0361-3682.

DAVILA, T., EPSTEIN, M.J., SHELTON, R. D. (2013). *Making innovation work: How to manage it, measure it, and profit from it*. Updated ed. Upper Saddle River: FT Press.

DRUCKER, P.F. (2009). *Management challenges for 21st century*. New York: Harper.

DYBÅ, T., DINGSØYR, T. (2009). What do we know about agile software development? *IEEE Software*, 26(5), 6-9.

FAGERBERG, J., MOWERY, D. S., NELSON, P.R. (2005). *The Oxford handbook of innovation*. Oxford: Oxford University Press.

GAILLY, B. (2011). *Developing innovative organizations: a roadmap to boost your innovation potential*. Hampshire: Palgrave Macmillan.

GALLOUJ, F., WEINSTEIN, O. (1997). Innovation in services. *Research Policy*, (26), 537-566. ISSN 0048-7333.

GARCIA, R., CALANTONE, R. (2002). A critical look at technological innovation typology and innovativeness terminology: A literature review. *Journal of Product Innovation Management*, 19(2), 110-132. ISSN 1540-5885.

GAULT, F. (2013). *Handbook of innovation indicators and measurement*. Cheltenham: Edward Elgar Publishing.

HENDL, J. (2012). *Přehled statistických metod: analýza a metaanalýza dat*. [Survey of statistical methods: data analysis and meta-analysis] Praha: Portál.

HORVÁTH & PARTNERS. (2002). *Balanced Scorecard v praxi*. [Balanced Scorecard in practice] Praha: Profess Consulting.

CHESBROUGH, H. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Boston, MA: Harvard Business School.

CHIESA, V., FRATTINI, F. (2009). *Evaluation and performance measurement of research and development*. Cheltenham: Edward Elgar Publishing.

KAPLAN, R. S., NORTON, D. P. (1996). Using the balanced scorecard as a strategic management system. *Harvard Business Review*, 74(1), 75-85. ISSN 0017-8012.

KEEGAN, D. P., EILER, R. G., JONES, C. R. (1989). Are your performance measures obsolete? *Management Accounting*, 70(12), 45-50. ISSN 0025-1682.

KERSSENS-VAN DRONGELEN, I. C., NIXON, B., PEARSON, A. (2000). Performance measurement in industrial R&D. *International Journal of Management Reviews*, 2(2), 111-143. ISSN 1468-2370.

KERZNER, H. (2017). *Project Management: Case Studies*. Hoboken, New Jersey: John Wiley & Sons.

KISLINGEROVÁ, E. (2008). *Inovace nástrojů ekonomiky a managementu organizací*. [Innovation of economics tools and management of companies] Praha: C.H.Beck.

MAIRESSE, J., MOHNEN, P. (2004). The importance of R&D for innovation: A reassessment using French survey data. *Journal of Technology Transfer*, 30(1), 183-197. ISSN 0892-9912.

MAITAL, S., SESHADRI, D.V.R. (2007). *Innovation management: Strategies, concepts and tools for growth and profit*. London: Sage Publications.

McCONNELL, S. (2004). *Code complete. A practical handbook of software construction*. Redmond, WA: Microsoft Press.

MEEUS, M. T. H., EDQUIST, C. (2006). Introduction to part I: Product and process innovation. In HAGE, J., MEEUS, M. (eds.) *Innovation, science, and institutional change*. Oxford University Press, 27-37. ISBN 978-0-19-929919-5.

MILES, I. (2001). Services innovation: A reconfiguration of innovation studies. *PREST Discussion Paper No. 01-05*, University of Manchester.

MYSLÍN, J. (2016). *SCRUM. Průvodce agilním vývojem software*. [SCRUM. Guide to agile software development] Praha: Albatros Media.

NIVEN, P.R. (2014). *Balanced scorecard evolution: a dynamic approach to strategy execution*. Hoboken, New Jersey: John Wiley & Sons.

NEELY, A., MILLS, J., PLATTS, K., GREGORY, M., RICHARDS, H. (1996). Performance measurement system design: Should process based approach be adopted. *International Journal of Production Economics*, 46-47(1), 423-431. ISSN 0925-5273.

NUTCACHE. (2019). *With great tools, comes great productivity*. Retrieved from: www.nutcache.com

OECD. (2005). *Oslo manual: guidelines for collecting and interpreting innovation data*. Paris: OECD Publishing.

OECD. (2009). *Innovation in firms*. Paris: OECD Publications.

PARMENTER, D. (2015). *Key performance indicators: developing, implementing, and using winning KPIs*. Hoboken, New Jersey: John Wiley & Sons.

PEARSON, A.W., NIXON, W., KERSSENS-VAN DRONGELEN, I. C. (2000). R&D as a business – what are the implications for performance measurement? *R & D Management*, 30(4), 355-364. ISSN 1467-9310.

SELECT BUSINESS SOLUTION. (1988-2019). *Select Business Solution*. Retrieved from: www.selectbs.com

SENGE, P. (2005). *The fifth discipline: the art and practice of the learning organization*. New York: Doubleday.

ŠOCHOVÁ, Z., KUNCE, E. (2014). *Agilní metody řízení projektů*. [Agile methods of project management] Brno: Computer Press.

THOMASCHEWSKI, D., TARLATT, A. (2010). Determinants for failure and success in innovation management. In GERYBADZE, A. et al. (eds). *Innovation and international corporate growth*. Berlin: Springer, 127-149. ISBN 978-3-642-10822-8.

TRIAS DE BES, F., KOTLER, P. (2011). *Winning at Innovation: The A-to-F Model*. Palgrave Macmillan.

VALENTA, F. (1969). *Tvůrčí aktivita – inovace – efekty*. [Creative activity – innovation – effects] Praha: Svoboda.

VERBEEK, A., DEBACKERE, K., LUWE, M., ZIMMERMANN, E. (2002). Measuring progress and evolution in science and technology I: The multiple uses of bibliometric indicators. *International Journal of Management Reviews*, 4(2), 179-211. ISSN 1468-2370.

WINGATE, L.M. (2015). *Project management for research and development: guiding innovation for positive R&D outcomes*. Boca Raton: CRC Press.

YUSOF N.A., SHAFIEI, M.W.M., SAID, I. ABIDIN, N. Z. (2010). Factors Influencing Firms´ Readiness Towards Innovation in House Building Industry: A Multi-Dimensional Construct. *International Journal of Organizational Innovation*, 2(3), 74-88. ISSN 1943-1813.

ŽIŽLAVSKÝ, O. (2016). *Innovation Scorecard: Conceptual Performance Measurement and Management Framework for Innovation Process*. Brno: Vutium Press.

Digitalisation impact Measuring on claim Management for the Insurance Sector

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Abstract

Purpose of the article The aim is to investigate the impact of digital transformation on the insurance sector for claim management and claim reserves using the data from non-life insurance companies located in Baltic countries. The object is digitalisation measurement in claim management. The subject is non-life insurance companies in Baltic countries (Estonia, Latvia, and Lithuania).

Methodology/methods Regression analysis, comparative methods, and Pearson correlation analysis were applied to explore the impact of digitalisation on claims regulation speed, and claim reserves. Authors have also used actuarial methods like the development factor method using aggregate paid claims triangles.

Scientific aim is to provide a discussion of how digitalisation can be measured for insurance sector claim management. Authors have proposed to use claim handling speed as the digitalisation measure. The following hypotheses were advanced in the current study: H1: Claim handling speed, impact of digital transformation depends on technical provisions structure in company's portfolio; H2: Claim handling speed, impact of digital transformation depends on claims paid volume; H3: There is a positive relationship between quick claims paid ratio (claims paid in one year period over total paid claims), the impact of digital transformation and Baltic countries GDP per capita.

Findings All three hypothetical propositions are accepted by authors using the correlation analysis method with 0.05 significance level and regression analysis. Digitalisation's signs can be seen in Baltic non-life insurers' annual financial reports in years 2011-2017. Digitalisation transformation goes in line with economic growth. In 2011, 74% of total paid claims were paid within one year, and in 2017 the amount was 79%. The correlations results showed that digitalisation has positively impacted claim handling speed.

Conclusions This study has its limitations in the scope of data used, the results show 80% of market share (using seven observations) and analyse non-life insurers in Baltic countries.

Keywords: insurance, solvency II, claim management, actuarial science, digitalisation, claim best estimate, claim handling speed, claims paid ratio.

JEL Classification: C58, G22, G32

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Introduction

Digitalisation transformation has just reached the insurance sector, which has become more information technology driven. Increasing competition, fintech, and insurtech start-ups' innovations are reasons why insurance companies must improve and develop their services in order to ensure business continuity. Lemonade is operating in fintech and has announced its plans to expand in Europe by using an entirely different business model compared with a traditional model (Lemonade, 2018). The insurance sector in the European Union is also facing new upcoming regulator rules. Solvency II regulates how much capital insurers should hold with 99.5 percentage confidence level using value at risk measure. It has new updates at least once in three years, and regular reporting is time-consuming. IFRS 17, with the effective year 2022, will entirely change the way how key insurance indicators are measured (Deloitte, 2017). Insurers must also implement general data protection, IFRS 9, packaged retail investment and insurance-based products regulation. All these aspects increase workload in support units. Staying in the market without digital transformation could be impossible.

Porter (1985), Rahlfs (2007), Eling & Lehmann (2017) provide an insurance-specific value chain where primary and supporting activities necessary for insurance products delivery are distinguished. Under support activities are units like IT, human resources, business controlling, legal department, public relations. Under primary sources are units like marketing, product development, sales, underwriting, customer service, claim management, asset risk management. We analyse the claim management part from primary sources. Authors also think that claim handling digitalisation must be the priority and must be mentioned in business strategy. A positive customer experience after the insured event can be the main reason for policy renewal. Cebulsky, Günther, Heidkamp & Brinkmann (2017) have reminded that insurance is more than selling a policy, and pricing must be with correct risk assessment; potential loss levels for the insurer need to be controlled through risk management, claims need to be verified, loss adjustment and payments need to be done, and regress needs to be efficiently processed.

Better understanding of the claim and reserving policy, handling, and future development helps in adequately assessing measurable underwriting risks. This also helps in developing an internal capital model that takes into account dynamic market changes and improves enterprise risk management in a company. Companies' enterprise risk management (ERM) frameworks are considered in the rating process in external rating agencies, for example, Standard and Poor's (2013), Moody's (2019), and A.M. Best (2018). External credit agencies have an increased focus on ERM (Aebi, Sabato & Schmid, 2012; Lundqvist & Vilhelmsson, 2018).

This study's aim is to examine the impact of digital transformation on the insurance sector in the area of claim handling, using the non-life insurance companies' data located in Baltic countries (Estonia, Latvia, and Lithuania).

This paper, thus attempts to provide answers to the following research questions: how digitalisation transformation impact can be measured in the insurance sector for claim management? What is the relationship between claim handling speed (digitalisation measure), claims paid volume (business growth), and the gross domestic product (GDP) in Baltic countries? Also, is companies' product and technical provisions structure impacting digitalisation's effectiveness? Authors have proposed to use claim handling speed as a digitalisation measure. The authors of this paper, therefore, make the following hypothetical propositions for this study:

- H1: Claim handling speed (digitalisation measure) depends on the technical provisions structure in a company's portfolio.
- H2: Claim handling speed (digitalisation measure) depends on claims paid volume (business growth).
- H3: There is a positive relationship between quick (in one year) paid claims ratio and Baltic countries' GDP.

Regarding the structure of this paper, we begin with a review of the literature on research problems and questions (Section 1). We then continue with a short description of our research methodology (Section 2). Finally, we discuss potential areas of work, both practitioners' and from researchers' perspectives, and the results of the hypothesis acceptance or rejection (Section 3).

1 Literature Review

Authors propose to use the 'digitalisation' definition of 'a process of creating value in a new business environment' proposed by Dorner & Edelman (2015). EY (2017) proposes to define the term 'digital transformation' as capitalising on the power of technology to revisit business models, acquire customers on new channels and create

essential user experiences. Eling & Lehmann (2017) have summarised the impact of digitalisation on an insurer's value chain with respect to this research scope, primary activities, and claim management in Table 1.

Table 1 Impact of digitalisation on claim management

Value chain process	Tasks	Impact on the value chain
Claims management	Investigation of fraud Claim settlement	Artificial intelligence and big data: • Prevention of fraud through data analytics • Automated calculation and pay-out of the amount of damage Blockchain: • Storage of the information for the automated pay-out • Mobile devices with apps: • Customers file their claims via smartphones

Source: Eling & Lehmann, 2017

We have reviewed the academic literature by searching for the term "digitalisation & insurance & claims" in the journal databases Web of Science and Scopus and did not identify research related to digitalisation effectiveness or progress in the Baltic and Nordic European countries or non-publicly traded insurance companies. Busquets (2018) published research on the company Multiasistencia, which manages a network-based service called the "Comprehensive Claim Management Service" (CCMS) and was a case study for transforming the digital ecosystem.

After searching for the term "digitalisation & insurance" in the journal databases Web of Science and Scopus, we wanted to highlight the research published by Bohnert, Fritzsche & Gregor (2019). Paper studies 41 publicly traded European insurance companies expressing a digital agenda in annual reports (2007-2017) are analysed and positive correlations can be seen (Bohnert, Fritzsche & Gregor, 2019). Currently, the most digitalisation-affected line of business is health insurance. There is no need even to report a claim as medical services are paid for using electronic insurance cards (pay-as-you-live), reasons for which being a small number of frauds, high-frequency volume, and low severity. Research by Yamamoto (2016) describes a conflict of interest in Japan between public interests and privacy protection, caused by using databases for health insurance claims. Leppert, Gerlach, Ostwald & Greiner (2018) summarise the weaknesses and strengths of Germany's digital health economy where the main weakness is a lack of business models, and private users only have a small willingness to pay for digital services.

For other lines of business, it is possible to buy policy or report claims using a mobile application without human interaction. Fintech and insurtech companies are focused on the customer experience. Regarding claim management, insurtech companies like Claimable (2019) offer an entire process of claims management to insurers by applying artificial intelligence. Authors think that insurtech companies are increasing customer experience satisfaction and traditional insurance model companies can quickly learn from them or acquire these new start-ups. Traditional insurance companies can also invent new ideas much faster due to capital surplus.

The authors have not identified how quantitative studies are changing the claim payment pattern, claim handling speed, and technical reserving structure overall in the market due to digital transformation. Analyses are performed on company profitability levels. The main advantages are fewer human errors (operational risk decrease) and handling claims consistently across the organisation (KPMG, 2017). McKinsey (2015) has ana-lysed that due to claim management, IT automatisation costs can be reduced by 40%. The disruptive technology change allows for cutting up to 10% in premium costs and 8% in claims expenses (BCG, 2018). The combined ratio would have a rapid decrease.

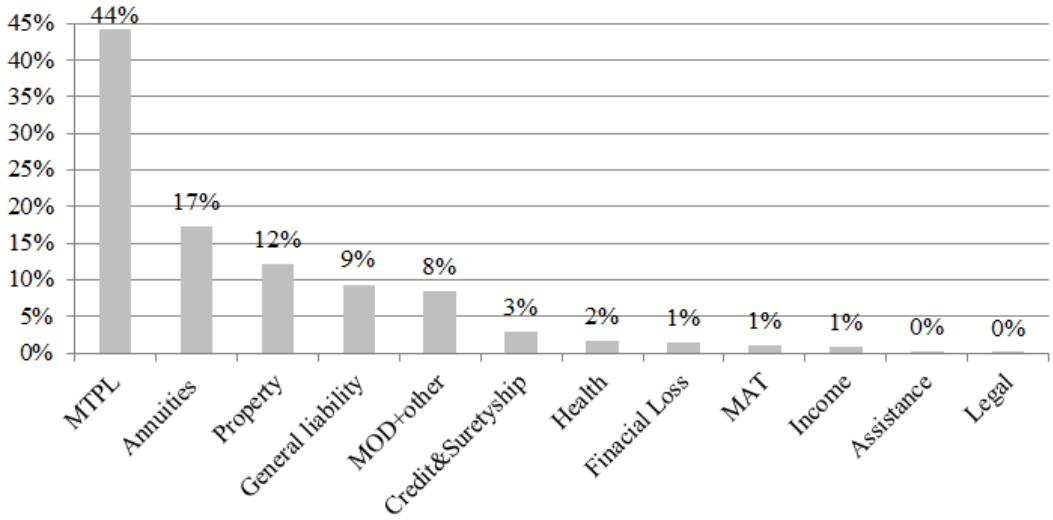
2 Methodology

The study population comprises the seven top non-life insurance companies in Estonia, Latvia, and Lithuania. The sample of seven non-life insurance companies includes Balta (2017), BTA (2017), ERGO (2017), AB Lietuvos draudimas (2017), Gjensidige (2017), Swedbank (2017), and IF (2017). The sample consists of subsidiary companies for group companies with headquarters in Sweden, Norway, Austria, Poland, and Germany. Data was obtained from publicly available annual reports of 2011–2017 and Solvency and Financial Condition reports

(SFCR) in 2017. The following hypothetical propositions for this study are chosen: H1: Claim handling speed (digitalisation measure) depends on the technical provisions structure in a company's portfolio; H2: Claim handling speed (digitalisation measure) depends on claims paid volume (business growth); H3: There is a positive relationship between quick (in one year) paid claims ratio and Baltic countries' GDP. This study employed a descriptive research approach. Data collected were analysed using the Pearson correlation analytical method, the Chain Ladder method, and the comprehensive method.

Total gross written premium volume for Baltic non-life insurance in the year 2017 is 1301.95 million EUR (EIOPA, 2018). The sample of seven non-life insurance companies creates an 80% market share. The rest of six companies have the remaining market share. Dissimilarity index in years 2015-2017 are the following: 27.77%, 27.28%, 26.51%. The market is profitable in the year 2017, with a combined ratio of 92%. There are similar performance indicator results also for previous years and for 2018. Claim reserves are the main position in the balance sheet for non-life insurers. Reserve risk is identified as one of the main risks why companies have become insolvent and failed (Leadbetter & Stodolak, 2009). In order to avoid deficient loss reserves, understanding the digital transformation impacting claim patterns and developments is crucial.

The sample subject claim's best estimate structure can be seen in Figure 1. Almost half of the reserves, 44%, are for motor third-party liability line of business, 17% for long term liabilities (annuities from motor third-party liability line of business), 12% for fire and property damage, and 9% for general third-party liability. The last line of business in the claim's best estimate, above the 5% floor, is motor and other own damage, with an 8% part in structure.



Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017

Figure 1 Claim reserves structure year 2017

One of the primary ways to assess digitalisation impact from a claim management aspect is by analysing paid claim triangles. A claim development triangle represents the volume of claims paid in an accident year and a certain financial year. It represents how much of the total paid claims in the financial year are paid from the same accident year, from previous accident years, and so forth. The more claims paid in the same financial year when an event occurred yields a more effective claim handling digitalisation transformation process. The market triangle, in this case, is created from publicly available annual reports of 2011–2017 and the Solvency and Financial Condition Reports (SFCR) in 2017. Percentage from total paid claims (including not yet reported claims) can be calculated using the well-known actuarial reserving method Chain Ladder. It is a simple and distribution free approach (Mack, 1993). Simple triangle example can be seen in Table 2.

Table 2 Market aggregated claim paid triangle in millions EUR

		Development year						
	Year	0	1	2	3	4	5	6
Claim accident year	2011	183.3	242.1	249.1	254.4	257.0	257.9	258.4
	2012	219.0	279.7	286.5	289.2	290.1	290.8	
	2013	238.0	302.0	308.5	311.5	314.1		
	2014	269.7	351.0	363.8	367.6			
	2015	321.0	407.6	415.1				
	2016	377.4	468.3					
	2017	399.5						

Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017

3 Results and Discussion

Hypothesis 1

In an attempt to justify the relationship that exists between claims regulation speed and claim reserve portfolio structure, a Pearson correlation technique was employed. This hypothesis helps to understand that despite digitalisation there can still be a line of business that needs more time due to a variety of reasons (court cases, legal requirements, and complicated processes for cause identification of risk). The test procedure is as follows:

- First, authors have divided claim reserves for the year 2017 into two parts: fast and slow handling. Medical expense insurance, income protection insurance, other motor insurance, fire and other damage to property, legal expenses insurance, assistance, miscellaneous financial loss claim reserves are under fast regulation group. Motor vehicle liability insurance, marine, aviation and transport insurance, general liability insurance, credit and suretyship insurance, annuities claim reserves are under slow regulation group, and for this hypothesis, their data are excluded.
- The quick paid claim ratio is calculated using an aggregated cumulative paid claim triangle for each company separately. The ratio shows how much of total claims paid amount is paid in the first year. The authors assumed the quick paid ratio is a digitalisation measure in claim management.

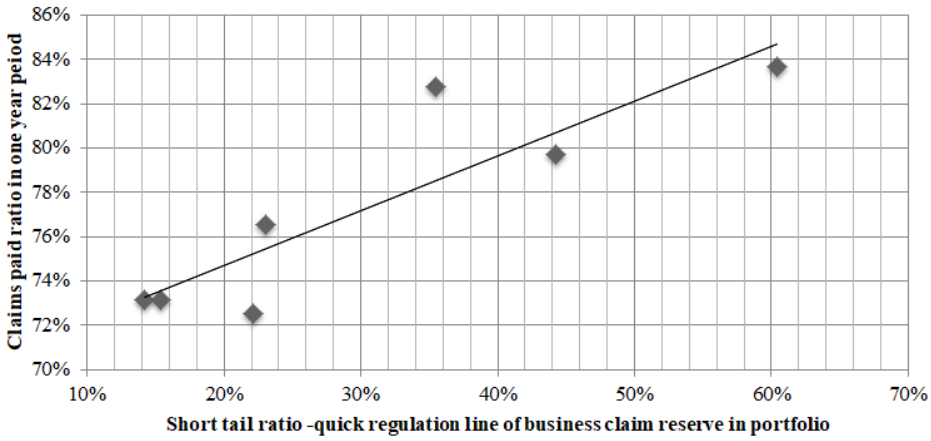
It is possible to calculate how much is paid from total claims in a one-year period using the chain-ladder method. By comparing it year-to-year, it is possible to access the digitalisation impact for each company and the market overall.

Since the correlation result is significant with 0.05 level of significance (i.e., a p-value of 0.007), and the generated result has less than 0.05 significance level in the study, the null hypothesis is accepted, and the alternative hypothesis is thus rejected.

Table 3 Pearson correlation matrix

	Claim reserve ratio with a short tail in a portfolio	Quick paid claim ratio
Claim reserve ratio with a short tail in a portfolio	1	88.69%
Quick paid claim ratio	88.69%	1

Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017

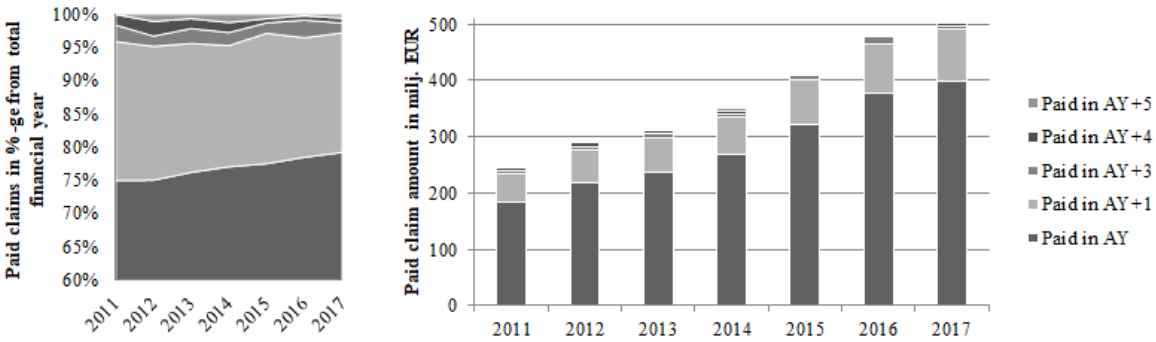


Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017

Figure 2 Strong positive relationship between the speed of claim regulation and reserve portfolio structure

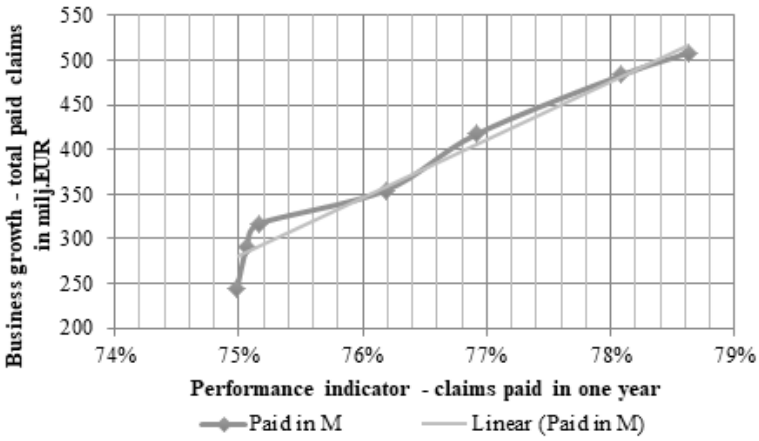
Hypothesis 2

In an attempt to justify the relationship that exists between claims regulation speed and business increase (paid claim volume), a Pearson correlation technique was employed. This hypothesis helps to understand that despite business growth, the increase of claims paid, claims regulation speed also increase. The test procedure is as follows: Claim amount paid in accident year, one year after the accident year, two years after the accident year, and so on is calculated for each year using market aggregate claim triangle. Then, the quick paid ratio is also calculated.



Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017

Figure 3 Payment pattern and paid claims in financial years 2011-2017 for each accident year



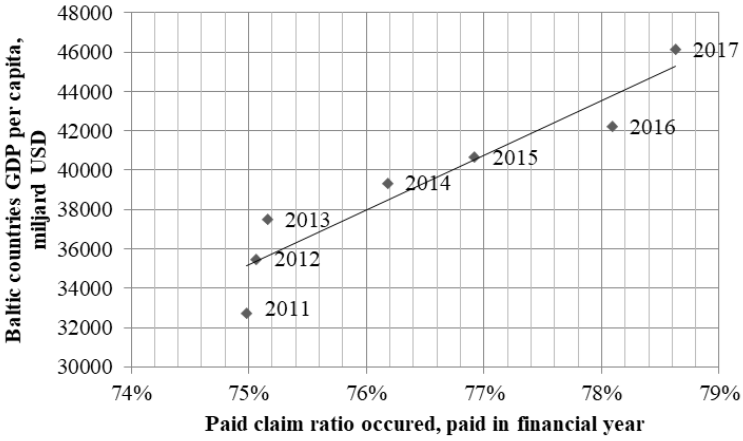
Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017

Figure 4 Signs of digitalisation impact - Total paid claims (business growth) and performance indicator - claims paid in one year period

There is a strong positive correlation between total claims paid and claims paid in a one year period divided by total claim volume - 98%. Since the correlation result is significant with 0.05 level of significance (i.e., a p-value of 0.0000, R square 96.31%) and the generated result is less than 0.05 significance level of the study, the null hypothesis is accepted, and the alternative hypothesis is thus rejected. Market data clearly shows that claim handling speed, and digitalisation transformation impact are increasing year to year. In 2011, 74% of total claims paid claims were paid in a year, in 2017, this was - 79%.

Hypothesis 3

In an attempt to justify the relationship between GDP and quick paid claims ratio regression analysis is per-formed. Hypothesis 3 states that there is a strong positive relationship between fast claims paid (in one year pe-riod) ratio and Baltic countries GDP per capita from 2011-2017.



Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017 and GDP per capita World Bank, 2019

Figure 5 Quick paid claim ratio and Baltic countries GDP per capita

There is a strong positive correlation between Baltic GDP per capita and digitalisation measure (claims handling speed in one year period from total claims paid) - 94%. Since there is a the correlation, the result is significant at with 0.05 level of significance (i.e., the p-value of 0.0000) and the generated result is less than 0.05 significance level of the study, the null hypothesis is accepted, and the alternative hypothesis is thus rejected. Regression analyses also show a good fit (R square is high 88.79%, $F_{critical}$<F). Digital transformation's products and services

will add 0.8% annually to the Asia Pacific's region's GDP by 2021 (Jimenez, Lim, Cheok & Ng, 2018). Authors have not found a forecast related to digital transformation impact on the European Union's GDP.

Table 4 Regression analysis results

Regression Statistics	
Multiple R	**94.23%**
R Square	**88.79%**
Adjusted R Square	86.55%
Standard Error	0.55%
Observations	7

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.6396	0.0199	32.0866	**0.0000**
GDP per capita mrd.EUR	0.0000	0.0000	6.2932	0.0015

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.0012	0.0012	**39.6040**	**0.0015**
Residual	5	0.0002	0.0000		
Total	6	0.0013			

Source: Calculations performed by the authors based on Baltic insurance companies' SFCR reports, 2017

Conclusion

This study attempted to examine the relationship between the digitalisation transformation impact on claim management for insurers and technical provisions structure, total claims paid volume and GDP per capita in Baltic countries. All three hypothetical propositions are accepted by authors using the correlation analysis method with a 0.05 significance level and regression analysis. The first accepted hypothesis proved that claim handling speed depends on a portfolio, and claim best estimate structure. Legal environment, large claims can decrease digitalisation effectiveness on claim management; thus, human interruption will still be needed. The second accepted hypothesis proved that despite business growth and paid claims increase, claim handling speed also increases. Analysis showed that there is a strong positive correlation. Claim handling speed and the first-year claim payment pattern has increased by 4% during 2011-2017. The third hypothesis showed that the insurance sector has started to use more digitalisation transformation tools with the growing economies in Baltic countries. The findings of the study show positive digitalisation signs in claim management. Financial annual reports represent the effect of faster claim regulation, and faster notification using mobile applications and QR codes in Baltic countries.

The research presupposes that further studies should focus on cost ratio changes, reserve risk assessment under the Solvency II framework, taking into account that, based on standard formula solvency capital requirement is calculated only for next 12 months. Moreover, it would be desirable to study how digitalisation transformation can be integrated into enterprise risk management, reserve risk assessment, and internal capital models, using blockchain, big data analytics, and the more precise risk aggregation technique 'copula approach' and 'tail dependence'.

References

AB LIETUVOS DRAUDIMAS. (2017). Annual reports (2011-2017) and SFCR report (2017). Retrieved from https://www.ld.lt/privatiems- klientams/apie-kompanija/finansiniai-rezultatai

AM BEST. (2018). *Best's credit rating methodology*. Retrieved from http://www3.ambest.com/ambv/ratingmethodology/default.aspx

BALTA. (2017). *Annual reports (2011-2017) and SFCR report (2017)*. Retrieved from http://www.balta.lv/lv/par-mums/darbibas-rezultati

BCG. (2018). *The First All-Blockchain Insurer*. Retrieved from https://www.bcg.com/publications/2018/first-all-blockchain -insurer.aspx

BOHNERT, A., FRITZSCHE, A., GREGOR, S. (2019). Digital agendas in the insurance industry: The importance of comprehensive approaches. *Geneva Papers on Risk and Insurance: Issues and Practice*, 44(1), 1-19. Doi:10.1057/s41288-018-0109-0

BTA. (2017). *Annual reports (2011-2017) and SFCR report (2017)*. Retrieved from https://www.bta.lv/lv/about/finansu-raditaji#-2016-gads

BUSQUETS, J. (2018). Multiasistencia: Transforming the digital ecosystem. *Journal of Information Technology Teaching Cases*, 8(2), 97-109. Doi 10.1057/s41266-017-0029-z

CEBULSKY, M., GÜNTHER, J., HEIDKAMP, P., BRINKMANN, F. (2017). *The digital insurance - facing customer expectation in a rapidly changing world*. In Digital marketplaces unleashed. Berlin, Germany, 359-370. ISBN 978-3-662-49275-8. Doi: 10.1007/978-3-662-49275-8_34

CLAIMABLE. (2019). I*ntroduction*. Retrieved from: https://www.claimable.com/how-it-works

DELOITTE. (2017). *The influence of IFRS17 on reward KPIs - volatility of pay parameters and new opportunities*. Retrieved from https://www2.deloitte.com/ content/ dam/ Deloitte/de /Documents/financial-services/ FSI_Influence-of-IFRS-POV.pdf

EIOPA. (2018). *Insurance statistics*. Retrieved from https://eiopa.europa.eu/pages/financial-stability-and-crisis-prevention/insurance-statistics.aspx

ELING, M., LEHMANN, M. (2017). The impact of digitalisation on the insurance value chain and the insurability of risks. *The Geneva Papers on Risk and Insurance — Issues and Practice*, 43(3), 356-396. Doi: 10.1057/s41288-017-0073-0

ERGO. (2017). *Annual reports (2011-2017) and SFCR report (2017)*. Retrieved from https://www.ergo.ee/fs-files/0000/0000/0002/files/SFCR%20report%20Non-Life%20EST%202017%20final%20web.pdf

EY. (2017). Digital transformation in insurance. Retrieved from https://www.ey.com/Publication/vwLUAssets/ey-digital- transformation -in- insurance/ $FILE/ ey-digital-transformation-in-insurance.pdf

GJENSIDIGE. (2017). *Annual reports (2011-2017) and SFCR report (2017)*. Retrieved from https://www.gjensidige.lt/apie-mus/finansiniai-rezultatai

IF. (2017). *Annual reports (2011-2017) and SFCR report (2017)*. Retrieved from https://www.if.ee/ifist/meist/finantsandmed

JIMENEZ, D., LIM, V., CHEOK., L., NG. H. (2018). *Unlocking the Economic Impact of Digital Transformation in Asia Pacific*. Retrieved from: https://3er1viui9wo30pkxh1v2nh4w-wpengine.netdna-ssl.com/wp-content/uploads/prod/sites/43/2018/11/Unlocking-the-economic-impact-of-digital-transformation.pdf

KPMG. (2017). *Clarity on Insurance Digitalization*. Retrieved from https://assets.kpmg/content/dam/kpmg/ch/pdf/clarity-on-insurance-digitalization-en.pdf

LEADBETTER, D., STODOLAK, P. (2009). *Why insurers fail. Inadequately pricing the promise of insurance*. Retrieved from http://www.pacicc.com/publications/pages/publications/WIF%20Inadequately%20Pricing%20Insurance.pdf

LEMONADE. (2018). *Europe, we're on our way*. Retrieved from https://www.lemonade.com/blog/coming-to-europe/

LEPPERT, F., GERLACH, J., OSTWALD, D. A., GREINER, W. (2018). Strength and weaknesses of the german digital health economy. [Stärken und Schwächen der digitalen Gesundheitswirtschaft]. *Gesundheitswesen*, 80(11), 946-952. Doi 10.1055/s-0043-112744.

LUNDQVIST, S. A., VILHELMSSON, A. (2018). Enterprise Risk Management and Default Risk: Evidence from the Banking Industry. *Journal Risk and Insurance*, 85 (1), 127-157. Doi 10.1111/jori.12151

MACK, TH. (1993). Distribution-free Calculation of the Standard Error of Chain Ladder Reserve Estimates. *Astin Bulletin*, 23, 213–225.

McKINSEY. (2015). *The Making of a Digital Insurer*. Retrieved from https://www.mckinsey.com/~/media/McKinsey/dotcom/client_service/Financial%20Services/Latest%20thinking/%20 Insurance/ Making_of_a_digital_insurer_2015.ashx

MOODY'S. (2019). *Enterprise Risk Management*. Retrieved from https://www.moodys.com/Pages/atc003002004.aspx

PORTER, M. E. (1985). *The Competitive Advantage: Creating and Sustaining Superior Performance*. New York: TheFree Press.

RAHLFS, C. (2007). *Redefinition Der Wertschöpfungskette Von Versicherungsunternehmen: Bewertungsmodell Zur Entscheidungsunterstützung Bei Der Disaggregation Der Wertschöpfungskette Am Beispiel Kleiner und Mittlerer Versicherungsunternehmen*. Germany, Wiesbaden: Deutscher Universitäts-Verlag.

STANDARD AND POOR's. (2013). *Enterprise Risk Management*. Retrieved from https://www.spratings.com/scenario-builder-portlet/pdfs/ICSB_Enterprise_Risk_Management.pdf

SWEDBANK. (2017). *Annual reports (2011-2017) and SFCR report (2017).* Retrieved from https://www.swedbank.ee/ about/ about/reports/annual/lifeins?language=ENG

WORLD BANK. (2018). *GDP per capita*. Retrieved from https://data.worldbank.org/indicator/NY.GDP.PCAP.CN? locations=EU-LV-LT-EE

YAMAMOTO R. (2016). Large-scale Health Information Database and Privacy Protection. *Japan Medical Association journal: JMAJ*, 59(2-3), 91-109.

SECTION 3
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MANAGEMENT IN DIGITAL TRANSFORMATION

Leadership Metaphors as expressions of Implicit Leadership Theories in Germany and the Czech Republic

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Abstract

Purpose of the article Implicit Theories about leader and follower or about leadership attributes and contexts are important to understand managerial leadership processes. In our attempt to understand leadership behaviours in Central and East European Countries (CEE), we address a widely neglected aspect of management behaviour in countries of transition. Metaphors of Leadership as specific culturally endorsed verbal expressions of Implicit Leadership Theories (ILT). Our comparative case study is theoretically based on the concept of Implicit Leadership Theories (e.g. Junker & van Dick, 2014) and influenced by Alvesson and Spicer's "Metaphors We Lead By" from 2011. Overall, we analysed 60 different newspaper articles. In this paper, we present our first results of this work-in-progress-project in form of two short country analyses, and a culture-comparative part. The country comparison of our results shows overlaps and differences in the use of Leadership Metaphors in both countries. On top of that, our study identified Leadership Metaphors that were not yet used in Alvesson & Spicer (2011) typology so far. So finally, we further develop this typology and proposed directions for further research.

Methodology/methods Data were gathered through the online access of Leipzig University Library and Brno University of Technology Library. The online database provided a comprehensive search function that helped to conduct a sound research process. First, we looked for representative newspapers of every political spectrum in each country. Then, we identified five overlapping areas in each of the newspapers. For Germany: politics, economy, society, sports and culture, for the Czech Republic: Our underlying assumption was that the article writers have used different metaphors for a respective area. Accordingly, we have selected two newspaper articles from each of these areas, published in 2018. Coding was done through MAXQDA.

Scientific aim Implicit Theories about leader and follower or about leadership attributes and contexts are important to understand managerial leadership processes. In our attempt to understand leadership behaviours in Central and East European Countries (CEE), we address a widely neglected aspect of management behaviour in countries of transition.

Findings Implicit Theories about leader and follower or about leadership attributes and contexts are important to understand managerial leadership processes. In our attempt to understand leadership behaviours in Central and East European Countries (CEE), we address a widely neglected aspect of management behaviour in countries of transition.

Conclusions With a closer look we can see that the factor in the German sample was dominate by the collaborative team orientation, which partly expressed participative behaviour either. On the contrary, to the GLOBE results, the administratively competent behaviour was found to be part of the German understanding of a transformational leader. The GLOBE methodology with its pre-defined factors and dimensions may have been an obstacle for the further in-depth analysis. The results for participative leadership have to consider this fact. If we take a closer look at notion of collaborative team orientation, which may indicate for some higher expectations towards participative leadership within the German sample. A Human orientation had the highest rating in the Czech sample and seemed to build a counterpoint to the strong focus on performance orientations and decisiveness. Finally yet importantly, the results for autonomous behaviour came close to the GLOBE results with the highest share for the Czech sample and close to the German sample.

Keywords: leadership, implicit leadership theories, CEE countries

JEL Classification: C35, C81, J24, M12, M14

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Introduction

Our comparative case study is theoretically based on the concept of Implicit Leadership Theories (e.g. Junker & van Dick, 2014) and influenced by Alvesson and Spicer's "Metaphors We Lead By" from 2011. Overall, we analysed 60 different newspaper articles. In this paper, we present our first results of this work-in-progress-project in form of two short country analyses, and a culture-comparative part. The country comparison of our results shows overlaps and differences in the use of Leadership Metaphors in both countries. On top of that, our study identified Leadership Metaphors that were not yet used in Alvesson & Spicer (2011) typology so far. So finally, we further develop this typology and proposed directions for further research.

2 Literature review

This relationship between Leadership Metaphors and Implicit Leadership Theories has not been investigated yet in depth. Although there are some country-based studies of the GLOBE, (Global Leadership and Organizational Behaviour Effectiveness) project (Chhokar, Brodbeck & House et al. 2007) that referred to typical cultural metaphors for leadership. Hoppe and Bhagat (2007) for example, characterized and compared the prototype of an American leader with characteristics of a cultural hero. Beyond this, we found no serious attempt and systematic analysis of Leadership Metaphors and their relations to Implicit Leadership Theories. Moreover, the literature on leadership metaphors mainly influenced by Alvesson and Spicer's "Metaphors We Lead By" (2011), treated leadership metaphors as universal expressions. A number of culture-comparative as well as single culture studies characterizes the literature focused on implicit leadership theories in CEE countries. The publications by scholars that have participated in the GLOBE project, plays a significant role. It can be divided into overviews about the theoretical background, methodologies and comparative results for all countries and regions involved in the project (e.g. Den Hartog et al. 1999; House et al. 2004; Dorfman et al., 2012). The publications also include results, which are relevant for Germanic and Eastern European Countries. The questionnaires collected in the frame of GLOBE project were completed by middle managers. Authors who focused their research on European countries like Konrad (2000) or Brodbeck at al. (2000) used the same basis of behavioural attributes. They compare similarities and differences of European regions, thereby highlighting different leadership expectations in Western and Eastern Europe. More in detail, the contributions of Bakacsi et al. (2002) or Weibler et al. (2001) and Szabo et al. (2002) analyse and compare countries of the East European Cluster, describing the special profile of leadership expectations of region and countries. Another analysis of CEE countries can be found in House (2002).

Chhokar, Brodbeck & House et al. (2013) published a volume with contributions of several countries that included not only a more detailed analysis of quantitative data, but also the results from qualitative studies. This comprised single and group interviews, texts about historical figures of the culture, and media analysis from which further information about culturally endorsed implicit leadership expectation. Therefore, the analysis of Brodbeck and Frese (2007) concerned with leadership and culture in Germany is of importance. Additional information about German patterns of leadership expectations can be found in Brodbeck et al. (2002).

Although the Czech data is not included as a part of GLOBE publications, they are available through the GLOBE data basis (http://globeproject.com/study_2004_2007#data). All of these sources show a number of typical characteristics of German leadership expectations. The expectations are characterized by specific patterns of charismatic or transformational leadership traits in which administratively competent behaviour plays an important role while team-oriented behaviour of lower importance (e.g. "humble collaborator"). There is a strong focus on clear, straightforward, and less subtle communication and task related performance instead of an orientation towards people (e.g. "low on compassion, high on performance"). At the same time, autocratic behaviour is rejected and subordinates, in contrast to nearly all CEE countries, including the Czech Republic, expect a high level of participation. Compared with other countries, Germans evaluates an autonomous leadership behaviour still as positive. It seems that only some CEE countries share this view. Findings about cultural expectations of Czech leaders point out to a higher acceptance of authoritarian styles of leadership, but also a stronger team orientation, and human leadership as well as more indirect and subtle behaviour (e.g., Konrad 2000, Brodbeck et al. 2000).

The Czech data shows a participative orientation close to those of German middle managers as well as a quite high level of acceptance of autonomous leadership behaviour. However, there was a stronger expectation towards team-oriented behaviour of the leader. The following table (Table 1) overviews the GLOBE implicit leadership theory dimensions of the respective samples of middle managers for Germany and the Czech Republic based on results of the GLOBE project.

Table 1 Implicit Leadership Theory Dimensions of GLOBE in the Czech Republic and Germany

	Czech Republic	Germany (East)	Germany (West)
charismatic / value based	5,91	5,87	5,84
team-oriented	5,87	5,51	5,49
human	4,58	4,60	4,44
autonomous	4,65	4,35	4,30
participative	5,85	5,70	5,88
Self-protective	3,13	3,32	2,96

Source: http://globeproject.com/study_2004_2007#data

Existing studies on implicit leadership theories in CEE countries evince many limitations. First, nearly all comparative data is developed in the frame of the GLOBE project. Many critical remarks have been made regarding the GLOBE measurement, also about various items, factors or dimensions (e.g., for the reverse measurement of participative leadership see Lang et al. 2014). One of the most remarkable critics, expressed by Hofstede (2010), is even questioning the validation of the GLOBE dimensions stating, that the GLOBE study did not explain external phenomena better than other studies before (Hofstede, 2010, p. 1345). Since GLOBE studies on Implicit Leadership Theories addressed only middle managers, just the leadership expectations of this social group has been researched1. Qualitative sources have been used only in an illustrative way, or transferred into countable measures (Chhokar et al. 2007). There was no reference to metaphor-like expressions in interviews nor a more detailed qualitative analysis of the interview material. However, at the same time, some authors have referred to the importance of leadership metaphors or images as expressions of a given culture. Hoppe and Bhagat (2007) compared the ideal positive prototype of an American leader with characteristics of a cultural hero and found many similarities. Holmberg and Akerblom (2001) showed that the role of mass media socially constructed the image of Swedish leaders. This is why we see a high potential and relevance for the analysis of Leadership Metaphors and Implicit Leadership Theories in media sources by the use of qualitative data.

With respect to implicit leadership theories (ILT), we follow the early argument of Shaw (1980) who has pointed to the inter- and cross-cultural relevance of cognitive categorizations of leadership attributes. Den Hartog et al. (1999), and other publications of the GLOBE project (e.g., House et al 2004, Chhokar et al. 2013, Dorfman et al. 2012) found that leadership leader attributes have to be differentiated in universal and culturally-contingent characteristics of an ideal leader. They suggested the term “culturally-contingent implicit leadership theories” (CLTs) to describe leader attributes that differs across cultures.

GLOBE defined six main dimensions of Implicit Leadership Theories (House et al. 2004: 675):

- Charismatic/value-based leadership: reflecting the ability to inspire, to motivate, and to expect high performance outcomes from others based on firmly held core values;
- Team-oriented leadership: emphasising effective teambuilding and implementation of a common purpose or goal among team members;
- Participative leadership: reflecting the degree to which managers involve others in making and implementing decisions;
- Humane oriented leadership: characterising a supportive and considerate leadership but also including compassion and generosity;
- Autonomous leadership: referring to independent and individualistic leadership attributes;
- Self-Protective leadership: focussing on ensuring the protection and security of the individual and group through status enhancement and face saving.

Especially the first two dimensions were found to be important in all cultures, although scholars stressed the differences of importance for these leadership behaviours. Self-protective leadership together with autocratic

leadership seem to be perceived as the negative prototype of leadership. However, like in other dimensions and factors, the authors referred to partly considerable cultural contingencies. Den Hartog et al. (1999) pointed to the fact that even the dimension of charismatic leadership show different factor constellations across cultures.

The majority of studies based their methodology on the GLOBE project, and we can track a tendency of using quantitative approaches in this field of research. For this reason, and as some of the other scholars, we would like to contribute to the interpretive, symbolic and image related parts of theoretical concepts of Implicit Leadership Theories (e.g. contributions of Keller 1999, 2003, Shondrick & Lord 2011, Foti et al. 2012). The goal of our study is to investigate the relation between Leadership Metaphors or Archetypes and Implicit Leadership Theories (e.g. Gabriel 1997, Neuberger 2002, Lindsey 2011).

The literature on leadership metaphors has a quite long tradition. Authors have pointed to the role of metaphors as cultural elements in the daily communication (e.g. Lakoff & Johnson 1980, 2003; Czarniawska 2004, or as an element in discourses that transports meaning (e.g. Fairhurst & Putnam 2004; Fairhurst 2005; Fairhurst & Grant 2010, Fairhurst 2010). We follow this way of thinking by interpreting metaphors as verbal accounts, which are attributed to an individual, a behaviour, a relation, an object, an event etc., by using references to other fields of live, like culture, nature, thinking etc. However, such references includes selective process, were speaker or author combine distinct thinking, various creations or references to a certain connotation. Language metaphors are therefore not only verbal expressions, but also categories of thinking, feeling, and experiencing (Liebert 2003). Through a creative use of the language, they contribute to the construction of a social reality in a certain field (Fairhurst & Grant 2010).

With respect to metaphors for leader or leadership, Jackson und Parry (2011) summarized the mentioned Leadership Metaphors: leadership as parenting, leadership as a teaching, and leadership as commanding or leading an army. Other authors like Gabriel (1997) referred to the God Metaphor for top leaders as seen by lower level employees. Another source of metaphors is literature about leadership archetypes. Neuberger (1995, 2002) for example refers to the archetypes of the father, the hero and the saviour or saint. We built our argument on Alvesson and Spicer's "Metaphors We Lead By" (2011). The authors referred to the following general metaphors of leadership close to central leadership roles (2011:49):

- Saint "provides moral guidelines and relations high on trust";
- Gardener "supports personal growth, helps people to improve themselves";
- Buddy "creates a working climate, where people feel good";
- Commander "creates clarity, is a powerful example for others to follow, sets direction";
- Cyborg "underscoring, machine-like rationality & efficiency, oriented towards results";
- Bully/Tyrant "providing sanctions including the intimidation of people".

Although the roles focus on prototypes of leaders, not on leadership, the reference to central roles also includes behavioural attributes, which can be used for an analysis of Implicit Leadership Theories. The Saint, for example, is described as a metaphor with integrity and trustworthy person, stands for an ethical leader, humane, morally guiding through communication and behaviour. The commander leads through behaviour that is planned, showing or setting directions, giving examples about what to do, but at the same time, is not easily to be influenced.

3 Main assumptions

With the identification and analysis of metaphors in texts about leaders and leadership in newspapers, we Implicit Leadership Theories of the authors of the material. The differences can be found either in the varying preferences for universal leader metaphors, behavioural attributes or divergent connotations. Furthermore, additional leader metaphors or behaviours, beyond the rather universal typology of Alvesson & Spicer (2011) or GLOBE can be interpreted as the expressions of a specific culture. Thus, our focus is on the identification of differences influence of leader metaphors and implicit theories.

Assumptions:

- the patterns of German metaphors as well as implicit leadership attributes will differ from the Czech sample;

- the German sample will be characterised by a higher preference for a future-planning, task-oriented, technical and administrative competent and autonomous leadership;
- the Czech samples will be characterized by a higher preference for the gardener and buddy metaphor than the German sample;
- the Czech sample will have a higher share of notions of team-oriented leader, like collaborative, team orientation or human orientation with a patriarchal style of leading;
- within the German sample, there will be a higher share of expectations towards a participative style of leadership than in Czech Republic.

4 Methods and sample

In the beginning, we gathered data through the online access of Leipzig University Library and Brno University of Technology Library. The online database provided a comprehensive search function that helped to conduct a sound research process. First, we looked for representative newspapers of every political spectrum in each country. Then, we identified five overlapping areas in each of the newspapers. For Germany: politics, economy, society, sports and culture, for the Czech Republic: Our underlying assumption was that the article writers have used different metaphors for a respective area. Accordingly, we have selected two newspaper articles from each of these areas, published in 2018. Coding was done through MAXQDA. As for the whole project, we have defined the following coding system:

- metaphors for leaders (persons)
- metaphors for leader attributes
- metaphors for leader behaviours' (activities)
- metaphors for leader (follower) relations
- metaphors for leadership processes
- metaphors for leadership contexts (situations)

In Germany, we identified articles with leadership accounts in the newspapers "Die Zeit", "Süddeutsche Zeitung" and "Frankfurter Allgemeine Zeitung". The analysis of the German sample lead to 183 metaphorical accounts. The data set from the Czech Republic consisted of articles published in the newspapers Moderni rizeni and Ekonom HN. Moreover, the analysis of the Czech sample lead to 72 metaphorical accounts. In a next step, all metaphors in the materials were paraphrased according to their meaning, and, and sorted to their appropriate meaning according to Alvesson and Spicer as well as to their implicit leadership attributes according to GLOBE. In case of indicated more than one leadership metaphor or implicit leadership attribute, we included these alternative metaphors or attributes in our analysis. For a first analysis, these alternative metaphorical expressions were sorted out. We finally summarized the total number of accounts for each country analysis as well as for the comparative analysis. Table 2 gives an example for our analytical approach. The coding list with working definitions and examples can be found in Annex 1.

Table 2 Coding of Leadership Metaphors and ILTs

Identified metaphors	Leadership codes	Paraphrase	Conotation (+/-)	Leader metaphor A./S.	IL Behaviour factor globe
have the feeling	A – attribute; B – behaviour	empathetic person and respective sensitive behaviours	+	buddy, garderner	humane
setting an example aligning	B – behaviour	leading through positive examples and clear communication	+	saint, commander	visionary, inspirational, team integrator, integrity

5 Main results

Overall, we found a number of 255 metaphors. In the process of analysis, it turned out that some of the metaphor dimensions overlapped and thus were interpreted and coded as metaphors for people, attributes or behaviour at the same time. This is why we focused on leader metaphors. The Leadership metaphors in the media showed a high

percentage of negative stereotypes of leaders. Consequently, the Bully or Tyrant is the dominant type of leader in this sample. A typical example is the behavioural metaphor to "Bring out the big hammer"; in which the Bildzeitung refers to Kim Yong-un, characterizing him as a person with ruthless behaviour and brutality in action to reach a goal; in this case to threat the USA with a nuclear bomb strike.

Metaphors of leaders and leading as Implicit Leadership Theories in Germany

The Buddy and the Cyborg also had a recognition of some 13%, respectively 11%. Interestingly, the commander was less important in mass media to get enough attention (see picture 1). One example is "Major Tom" as an autonomous, individualistic and future-oriented commander for an uncertain journey. This universal cultural metaphor based on David Bowies fictional astronaut refers to the German CEO of Airbus Tom Enders, who was about to resign. With the constant battle against Boing, he was about to release the group in an uncertain future. Beyond the Alvesson-Spicer-Typology, we found a number of additional leadership metaphors like the Hero (11%), the God (8, 8%) and the Grey Cardinal (7, 7%). The latter is characterised by often informal, hidden and clandestine leadership actions, while the hero was merely found in the context of leadership in sports. The behavioural metaphor "not to hide from" for example described a lead player of a hockey team, who actively take the lead in a critical situation of a final play. The high share of alternative types of leader metaphors like Hero, King, God, Agent, Doctor etc. challenged the Alvesson-Spicer typology and needs further consideration. Consequently, to the importance of negative types like the Bully or Tyrant, the self-protective leadership behaviour got the most references with around 32% of the leadership persons. Charismatic attributes and leaders were also quite often recognized (28% vs. 26%) while transformational leadership behaviour did not find much attention (around 15%). On the contrary, team-oriented leadership behaviours were more often mentioned (24, 5%). Participative and human leadership behavioural attributes instead score similar than in the interview analysis, with around 10% of the accounts. Moreover, autonomous, individualistic leader persons and personal attributes have been mentioned with around 12%. A comparison of the results from two sources revealed the specific character of mass media reports on leadership. The results show the focus but also the special contribution of mass media to the social construction of good and bad leadership, highlighting especially outstanding actors.

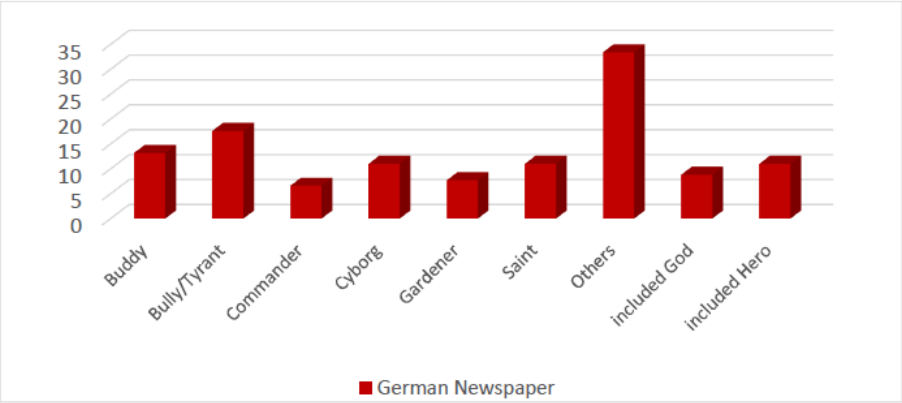

Figure 1 The patterns of Leader Metaphors used in German Newspaper Articles

5.1 Metaphors of leaders and leading as Implicit Leadership Theories in Czech Republic

The analysis of the Czech sample shows the dominant pattern of mainly positively connoted metaphors of a Commander and a Cyborg with more than 40% of all accounts (Table 3). Typical examples for leader metaphors were the "Commander", the "Pathfinder", the "Clever Head" or the "Executor". As behavioural accounts from the data, we found statements like "Keeping the line" or "Convincing about the right rules in the game". The commander type was also seen with more directive or strict forms of behaviours ("Give instructions and perceive the others as soldiers"), or even as negative prototype for leadership. One of the newspapers referred to an autonomous, directive and self-centred manager as "Captain Myself" (Ekonom_HN).

Beside the commander metaphor, around 15% of Gardeners and a certain share of the Buddy and Saint metaphor completed the Czech sample. Examples for this were a "Conductor" or a "Natural coach" as rather soft and gardening leaders of team members, or a "Wise fellow" as a Saint-like person. The Connector" was a person with a "Human face". Only a small number of Bullies or Tyrants were mentioned, mainly with an accent on bad

behaviour towards employees and autocratic decisions (about us or without us). However, the analysis also showed of other Leadership Metaphors beyond the Alvesson-Spicer Typology. We identified around 17% of overall accounts for types like Hero, God, Grey Cardinal or Doctor, with specific, additional attributes compared to the prototypes of Alvesson and Spicer (2011).

Table 3 Distribution of Leadership Metaphors in Czech Newspapers

	buddy	bully / tyrant	commander	cyborg	gardener	saint	others	within hero
number of accounts	7	3	13	12	9	7	10	5
%	11,5%	4,9%	21,2%	19,6%	14,6%	11,5%	16,8%	8,4%

5.2 Comparative results and discussion: universal or cultural contingent

Looking at the leadership metaphors in the texts of the both countries, we found a significant number of metaphors close to the universal types as discussed by Alvesson, Spicer (2011) and other scholars. The commander was a dominating metaphor in all countries, neglected in German mass media only. Together with the Cyborg, he may form a typical pattern for postsocialist leadership style: still relevant hierarchical plus efficiency orientation. Moreover, the Gardener metaphor was found among the metaphorical references, although with some noticeable variations over both samples. We could identify similar results for the Cyborg, who got the highest share of (relative) recognition in the Czech Republic and a rather low recognition in Germany. For the saint and the Buddy metaphor, we could also find some variations across both countries (Table 4). The Gardener got the lowest in recognitions in Germany, while the emphasis is more on the leadership metaphor type Saint. The Czech mass media showed the highest share for a Cyborg type of leadership, with its rule-based efficiency orientation. The negative prototype of the Bully and the Tyrant was not so much in the focus of the Czech samples but found more mentioning especially in German mass media.

Table 4 Country comparison between Germany and the Czech Republic

Leadership metaphors	buddy	bully / tyrant	commander	cyborg	gardener	saint
German newspaper	10,3%	11,0%	28,7%	10,3%	10,3%	16,2%
Czech Rep. newspaper	11,5%	4,9%	21,2%	19,6%	14,6%	11,5%
Globe ILT dimensions	charismatic / value based	team-oriented	human	autonomous	participative	self-protective
German newspaper	38,4%	32,0%	9,3%	9,3%	5,3%	5,3%
Czech Rep. newspaper	42,0%	14,7%	7,9%	17,0%	6,8%	10,4%

The material also allows some first remarks regarding the character of the material. The newspapers in both countries have a dominant focus on metaphors for leader people and tended to use more metaphors with a negative connotation. Somehow, there was a tendency to exaggerations and to extremes expressed in the usage of their metaphors. As results, the newspaper articles especially highlights the alternative prototypes of leadership metaphors like Hero, God, and Grey Cardinal etc. The latter was found in media reports only. This may also have to do with the inclusion of other fields of leadership like sports or politics, where the Hero metaphor was prominently mentioned in sports, as a team leader, and the Grey Cardinal in politics. Despite the similarities, a comparison of the results from included Czech and German media articles shows interesting differences (Figure 2).

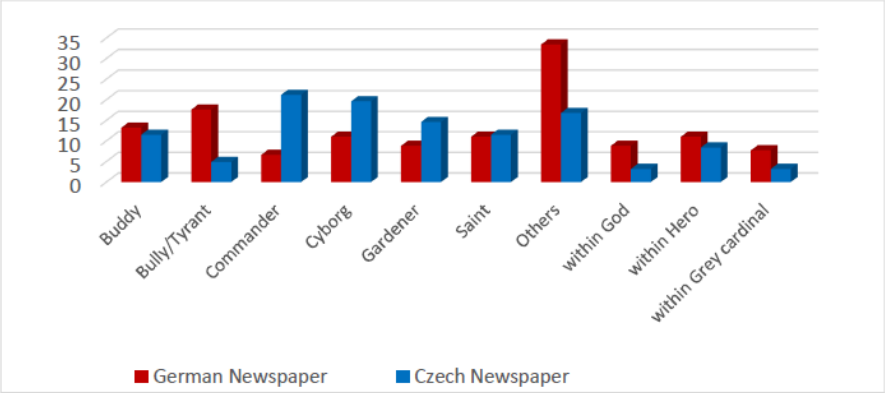

Figure 2 Leader Metaphors in German and Czech Newspapers articles in % of the total accounts

The German newspaper articles put more emphasis on types like Bully/Tyrant on the one hand and Buddy, Hero, Saint or Cyborg on the other hand, together with God, Doctor or Grey Cardinal. The distribution of patterns in Czech newspapers is closer to the Commander/Cyborg combination and the Gardener at the top, although the other prototypes play an important role. A possible reason can be the focus of selected newspapers. The focus of Czech media sources Ekonom_HN and Moderni Rizeni, is on economy and management questions, while the German newspapers Die Zeit, Süddeutsche and Frankfurter Allgemeine Zeitung is broader.

In some sources, we found metaphors that are referencing to fashions of modern management, like characterising the leadership relations as partnerships or as costumer relations, speaking about an open-door policy, or about the colourfulness as an expression of staff diversity, feedback or coaching. Typical cultural expressions of universal Leadership Metaphors were “Throw into deep water” or “Climbing a ladder” for instance.

With respect to the Implicit Leadership Attributes, we identified different profiles for all countries, beyond the dominating focus on charismatic or value-based leadership expectations in all countries. However, even the internal structure of these factors differed considerably. While the Czech results showed a combination of performance orientation and decisiveness, and the visionary and inspirational behaviour, the German sample had a high share of these factors (Table 4). However, with a closer look we can see that the factor in the German sample was dominate by the collaborative team orientation, which partly expressed participative behaviour either. On the contrary, to the GLOBE results, the administratively competent behaviour was found to be part of the German understanding of a transformational leader. The GLOBE methodology with its pre-defined factors and dimensions may have been an obstacle for the further in-depth analysis.

The results for participative leadership have to consider this fact. If we take a closer look at notion of collaborative team orientation, which may indicate for some higher expectations towards participative leadership within the German sample. A Human orientation had the highest rating in the Czech sample and seemed to build a counterpoint to the strong focus on performance orientations and decisiveness. Finally yet importantly, the results for autonomous behaviour came close to the GLOBE results (Table 1) with the highest share for the Czech sample and close to the German sample.

Limitations and further research directions

This paper is work-in-progress. We just started the analysis of the collected data. More systematic and more in-depth analysis will follow. Therefore, we see ourselves confronted with many obstacles for this paper. Firstly, the theoretical basis needs to be refined and clarified, especially the relation between Leadership Metaphors and Implicit Leadership Theories. To focus on metaphors of leaders can simplify the research, but to include also other dimensions, like leadership processes, relations or contexts can lead to some consequences for the methodology and the coding process, which have not been fully solved yet. In addition, we have to switch the data material internally and in order to have an international discussion and a foureye principal. Secondly, the sample structures as well the scope of the samples are another problem. It turned out, that especially mass media sources seemed to lead to a special focus of the authors. Such authors emphasized more interesting leadership metaphors and neglected other. On the other hand, media contributes substantially to the constructions of leadership ideals, and have to be analysed in more depth taking into account the institutional settings of each media source.

Thirdly, an in-depth analysis should also include interpretations of co notations of already existing models like those of Alvesson & Spicer, or underlying GLOBE model of leadership dimensions. Finally, in our first attempt, we focus on a quantitative overview, so to say quantifying the qualitative material. Further research may focus on the pattern found through this analysis, also on more qualitative analysis of some core metaphors by means of an interpretive approach.

References

ALVESSON, M., SPICER, A. (2011). *Metaphors We Lead By: Understanding Leadership in the Real World*. Thousand Oaks et al.

BAKACSI, G., TAKÁCS, S., KARÁCSONYI, A., IMREK, V. (2002). Eastern European cluster: tradition and transition. *Journal of World Business*, 37(1), 69–80.

BRODBECK, F. C., FRESE, M. (2007). *Societal culture and leadership in Germany*. In: CHHOKAR, J. S., BRODBECK, F. C., HOUSE, R. J. (Hg.): Culture and Leadership Across the World: The GLOBE Book of In-Depth Studies of 25 Societies. Mahwah, 147-214.

BRODBECK, F. C., FRESE, M., AKERBLOM, S., AUDIA, G., BAKACSI, G., BENDOVA, H. et al. (2000). Cultural variation of leadership prototypes across 22 European countries. *Journal of Occupational and Organizational Psychology*, 73(1), 1-29.

BRODBECK, F. C., FRESE, M., JAVIDAN, M. (2002). Leadership made in Germany: Low on compassion, high on performance. *The Academy of Management Executive*, 16(1), 16-30.

CHHOKAR, J. S., BRODBECK, F. C., HOUSE, R. J. (Eds.). (2013). C*ulture and leadership across the world: The GLOBE book of in-depth studies of 25 societies*. Routledge.

CZARNIAWSKA, B. (2004). *Narratives in Social Science Research*. London et al.

DEN HARTOG, D. N., HOUSE, R. J., HANGES, P. J., RUIZ-QUINTANILLA, A., DORFMAN, P. W. (1999). Culture specific and cross-culturally generalizable implicit leadership theories: Are attributes of charismatic/transformational leadership universally endorsed? *The Leadership Quarterly*, 10(2), 219-256.

DORFMAN, P., JAVIDAN, M., HANGES, P., DASTMALCHIAN, A., HOUSE, R. (2012): GLOBE: A twenty year journey into the intriguing world of culture and leadership. *Journal of World Business*, 47(4), 504-518.

FAIRHURST, G. T., PUTNAM, L. (2004). Organizations as discursive constructions. *Communication theory*, 14(1), 5-26.

FAIRHURST, G.T. (2005). Reframing the art of framing: Problems and prospects for leadership. *Leadership*, 1, 165.

FAIRHURST, G. T., GRANT, D. (2010). The social construction of leadership: A sailing guide. *Management Communication Quarterly*, 24(2), 171-210.

FOTI, R. J., BRAY, B. C., THOMPSON, N. J., ALLGOOD, S. F. (2012) Know thy self, know thy leader: Contributions of a pattern-oriented approach to examining leader perceptions. *The Leadership Quarterly*, 23(4), 702-717.

GABRIEL, Y. (1997) Meeting God: When organizational members come face to face with the supreme leaders. *Human Relations*, 50(4), 315-342.

HOFSTEDE, G. (2010). The GLOBE debate: Back to relevance. *Journal of International Business Studies*, 41(8), 1339-1346.

HOLMBERG, I., AKERBLOM, S. (2001). The production of outstanding leadership: An analysis of images expressed in Swedish media. *Scandinavian Journal of Management*, 17(1), 67-85.

HOPPE, M. H., BHAGAT, R. S. (2007). *Leadership in the United States of America: The leader as cultural hero*. In: CHHOKAR, J. S., BRODBECK, F. C., HOUSE, R. J. (Hg.) Culture and Leadership Across the World: The GLOBE Book of In-Depth Studies of 25 Societies. Mahwah, 475-544.

HOUSE, R. J., HANGES, P. J., JAVIDAN, M., DORFMAN, P. W., GUPTA, V. (2004). *Culture, Leadership, and Organizations: The GLOBE Study of 62 Cultures*. Thousand Oaks.

JACKSON, B., PARRY, K. (2011). *A Very Short, Fairly Interesting and Reasonably Cheap Book About Studying Leadership*. Los Angeles u.a

JAVIDAN, M., DORFMAN, P. W., DE LUQUE, M. S., HOUSE, R. J. (2006). In the eye of the beholder: Cross cultural lessons in leadership from project GLOBE. *The Academy of Management Perspectives*, 20(1), 67-90.

JUNKER, N. M., VAN DICK, R. (2014). Implicit theories in organizational settings: A systematic review and research agenda of implicit leadership and followership theories. *The Leadership Quarterly*, 25(6), 1154-1173.

KARÁCSONYI, A. (2006). *Leadership, organizational culture and their relationship: The case of Hungarian organizations*. Unpublished PhD work. Corvinus University of Budapest.

KELLER, T. (1999). Images of the familiar: individual differences and implicit leadership theories. *The Leadership Quarterly*, 10(4), 589-607.

KELLER, T. (2003). Parental images as a guide to leadership sensemaking: An attachment perspective on implicit leadership theories. *The Leadership Quarterly*, 14(2), 141-160.

KONRAD, E. (2000). Implicit leadership theories in Eastern and Western Europe. *Social Science Information*, 39(2), 335-347.

LAKOFF, G., JOHNSON, M. (1980, 2003). *Metaphors We Live By*. Chicago/London.

LIEBERT, W.-A. (2003). *Wissenskonstruktion als poetisches Verfahren. Wie Organisationen mit Metaphern Produkte und Identitäten erfinden*. In: Geideck, S., Liebert, W.-A. (Hg.): Sinnformeln. Linguistische und soziologische Analysen von Leitbildern, Metaphern und anderen kollektiven Orientierungsmustern. Berlin u.a., 83-101

LINDSEY, J. L. (2011). Fine art metaphors reveal leader archetypes. *Journal of Leadership & Organizational Studies*, 18(1), 56-63.

LORD, R. G., SHONDRICK, S. J. (2011). Leadership and knowledge: Symbolic, connectionist, and embodied perspectives. *The Leadership Quarterly*, 22(1), 207-222.

OBERLECHNER, T., MAYER-SCHOENBERGER, V. (2002). *Through their own words: Towards a new understanding of leadership through metaphors*. John F. Kennedy School of Government, Harvard University.

NEUBERGER, O. (2002). *Führen und führen lassen*. Stuttgart.

SHAW, J. B. (1990): A cognitive categorization model for the study of intercultural management. *Academy of Management Review*, 15(4), 626-645.

SZABO, E., BRODBECK, F. C., DEN HARTOG, D., REBER, G., WEIBLER J., WUNDERER, R. (2002). The Germanic Europe cluster: where employees have a voice. *Journal of World Business*, 37(1), 55-68

WEIBLER, J., SZABO, E., REBER, G., BRODBECK, F. C., WUNDERER, R. (2001). Values and behaviour orientation in leadership studies: Reflections based on findings in three German speaking countries. *Leadership Quarterly*, 12(2), 219-244.

Annex 1: Coding List for types of Leader Metaphors

Leadership metaphor	definition	Code examples from material
Saint	A person, attribute and/or behaviour that is a moral role model, provides moral guidelines and relations high on trust, altruistic, self-sacrificing	"You have to develop a certain fire, a passion for your goals" (German Manager about necessary attributes/behaviours of a good leader) "Philanthropist" (Czech Newspaper about a top manager) "I do my job with heart and hand" (self- description of a Hungarian Manager) "Not practice what he preaches" (Water & Vine/Negative notion of German Manager)
Gardener	A person, attribute and/or behaviour that support personal growth of others, helps people to improve themselves, works like a gardener, planting new things, support growing, but also correct wrong developments	"You should not put an introvert to the stage, push him to the sunshine, contrarily you should leave a bird of paradise on the stage" (Hungarian manager about his/her management philosophy) "They're supposed to lay the egg themselves instead of putting the egg into their nest" (German manager with Scandinavian roots), about leading subordinate managers) "Turn on the head to someone" (German Newspaper) "Support their [team member] development means of mine" (Hungarian Manager]
Buddy	A person, attribute and/or behaviour that creates a working climate, where people feel good, satisfaction-oriented, egalitarian attitudes, ignores hierarchical differences	"We have to see us here as a team" (German Manager about his management philosophy) "Family atmosphere" (Hungarian Manager of an SME) "Fertilizer of team activities" (Czech Manager) "Chatterbox" (Negative notion of a Czech Newspaper about a manager)
Commander	A person, attribute and/or behaviour creating clarity, acting forceful, gives a powerful example for others to follow, set direction, lower level of reflexivity, and tolerance for criticism	"If a leader cannot put herself to somewhere [Hungarian idiom], she is not ready to lead" (Hungarian Manager) "To bring them on the right way" (German Manager) "Captain Myself" (Negative connotation about a manager in Czech Newspaper) "I am just the captain and so the ship also runs for a few weeks, months without a captain, but the world sail does not succeed without a captain" (German Manager about his leader philosophy).
Cyborg	A person, attribute and/or behaviour that underscoring machine-like rationality and efficiency, orient towards results, focus on technical expertise, perfectionism	"Everyone in the gearbox has its task. -Probably a big wheel, but the small wheel is just as important as the big wheel. Otherwise the whole thing doesn't work" (German Manager) "I tend to do and execute the task myself that once I assigned." (Hungarian Manager) "Press on the brake or the accelerator" (German manager`s understanding of managerial action)
Bully/Tyrant	A person, attribute and/or behaviour that providing sanctions including intimidating people, lack of respect for others, malevolent, deceitful, bullying	"The flogger" (German Manager characterizing his boss) "Bossmentship" (Hungarian Manager for bad leadership) "Bring out the big hammer" (German Newspaper) "I had a toxic boss" (Hungarian Manager)
Hero	A person, attribute and/or behaviour acting as an individual, autonomous, forceful fighter, defends, rescue or save others, solving critical problems, is successful, famous, self-sacrificial	"Rocky" (German Newspaper about a Manager) "as good as Jarda Jágr [Czech famous hockey player]"(Czech Newspaper positively characterizing a manager) "Shield" (Czech Newspaper about a Manager)
God	A person, attribute and/or behaviour with supernatural abilities, stands above all, make unbelievable things happen, omnipotent, protective but also threatening	„to change the state of the clouds" "[he] is looking over the clouds" (German managers about their bosses) "See more and far than others" (Czech Newspaper about a top manager)
Father/mother or parents	A person, attribute and/or behaviour that combines a superior, strong and powerful role model for behaviour, with protective, caring and understanding behaviours for other, which where, in turn, constructed as immature children.	"I am the mother of the people in the firm" (German CEO Manager*in about her role) "Faithfulness until death" (Attribute in German media)
Doctor	A person, attribute and/or behaviour that compares leader with a professional person with healing abilities, able to help other out of a state of illness, prevents other for becoming ill.	"Surgeon" (Czech Newspaper about a manager) "Best prophylaxis" (German manager about planned action) "Do trauma research" (for Leader behaviour in German Newspaper)

Grey cardinal	A person, attribute and/or behaviour characterized through often informal, hidden and clandestine leadership actions.	"Guarantor" (for a Leader Person in German Media obliged to intervene in the background) "Play Poker" (describing a Leader `s Behaviour in German media) "Divide et impera", "Search for loopholes" (Czech Newspapers about negatively connoted manager behaviour) "Between sobriety, vanity and past government power but still in the first row" (Attribute for a Leader in German media).

Challenges and use of virtual tools in teamwork

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Abstract

Purpose of the article There have been many studies focusing on teamwork. However, the digital transformation has caused new challenges in this field. Thus, the aim of the article is to provide insight into the most significant challenges in virtual teamwork and to identify the used and known virtual tools.

Methodology/methods This study adopted a quantitative approach by means of questionnaire administered online. The final sample consisted of 622 respondents from two universities from Poland and Romania. The survey was conducted on January 2019. Students from several classes from the bachelor and the master pro-grams of all faculties of both universities were approached to respond to a survey.

Scientific aim The aim of the survey was to diagnose the students' experience in virtual teamwork, their challenges of working in this type of teams, and knowing and using of tools for virtual teamwork.

Findings The research results shows that almost half of the students (48,1 percent) have experience in virtual teamwork. Their experience is mainly regarding with preparing a project or a presentation for classes. However, the most used tools are these which are the most popular: messengers, mobile phone, social media like Facebook, e-mail and tool for creating folders and holding files like Google drive. Thus, one of the dimensions of challenges of work in virtual teams is insufficient knowledge of IT tools by team members and technology difficulties (e.g. software, computer, internet access).

Conclusions In the context of growing needs in this area, it seems important to support to acquire teamwork skills. It seems that the students learn to use virtual tools by the way doing of something for classes. Thus, the classes should teach students how to use of virtual tools to a greater extent, especially that some of the tools are well known but not used. Organizations might offer internships to enable students to develop skills in using specific virtual tools.

Keywords: teamwork, virtual tools, virtual team

JEL Classification: M12, M5

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Introduction

Globalization, economic fluctuations, cultural diversity, rapid environmental changes and improved networking and collaboration technologies are changing the way organizations operate their activity. The new challenges of competitiveness and the needs of the organization in terms of flexibility and adaptability cause an increase in the importance of team in an organization (Matwiejczuk and Samul, 2016).

In this context, many organizations try to implement virtual teams in order to sustain their competitive ad-vantage. The main reason is that virtual teams can do things collectively that collocated teams cannot. When valuable members are geographically dispersed, the adoption of virtual teams enables organizations to benefit from knowledge, skills, expertise and new perspectives that wouldn't be available for on-site collaboration. In other words, virtual teams have the potential to generate innovative and valuable results (Pinjani and Palvia, 2013) given the fact that they excel at idea-generation and brainstorming tasks, due to fewer interruptions and greater equality in participation among members (Martins et al., 2004).

Großer and Baumöl (2017, p. 298) highlight another important advantage for companies: they might gain from making good use of virtual teams with respect to organizational guidance and attracting a workforce, as it might be a style of work, which is appealing to the younger generation that have native digital skills. However, it is necessary to undertake studies that identify the perceptions of younger generation about working in virtual teams as well as their knowledge of virtual instruments used, so that companies can invest in a targeted way in their future employees in terms of trainings.

All the aforementioned benefits are based on the assumption that virtual teams are well designed, managed and implemented. But if little attention is paid to above-mentioned activities, then virtual teams will fail. Hence, identifying and understanding challenges faced by virtual team members is critical.

The paper is structured as it follows. The article starts with a literature review on virtual teams in terms of definition, virtual tools and main challenges. Then it is discussed the research methodology, followed by the results of the empirical study. In the end, implications and conclusions are presented.

1 Conceptual background

1.1 Virtual teams defined

Virtual teams are composed of members that are geographically dispersed, work interdependently and in-formation flows among members are enabled by communication technology, in order to achieve common goals and share outcomes. They have new types of work patterns, decision making styles, relationships (Alsharo et al, 2017), decentralized work processes and versatile structures (Bisbe and Sivabalan, 2017, p. 14) given that their members have different national and cultural backgrounds, expertise and organizational affiliation.

Some teams are completely virtual and have never met face to face, while others are slightly virtual in which team members primarily interact face to face, but also spend time working with each other through in-formation and communication technology (Wadsworth and Blanchard, 2015, p. 387). Gibson and Cohen (2003, p. 5) highlight that "just the use of technology does not make a team virtual, because all teams use technology". The level of virtuality is often determined by the degree of reliance on electronic communication and geographic dispersion of team members. Some researchers analyze geographic dispersion in terms of multiple dimensions: spatial distance, temporal (time difference) and configurational (sites, isolation and imbalance) (O'Leary and Cummings, 2007). Moreover, other researchers use the concept partially distributed team, a hybrid of virtual and co-located face-to-face teams that has at least one co-located subgroup and at least two geo-graphically-dispersed subgroups (Eubanks et al, 2016, p. 556 after Huang and Ocker, 2006).

However, as levels of team virtuality increase, the lack of communication richness, relative to face-to-face interactions, will pose greater challenges for such teams (Schaubroeck and Yu, 2017, p. 640). Anyway, it is hard to imagine in today's workplace environment teams in which the members do not have some level of virtuality.

Other studies highlight other types of virtual teams: inter-organizational teams and distributed ad-hoc task groups (Espinosa et al, 2007; Malhotra and Majchrzak, 2014). Also, some studies mention that team members may belong to the same organization or multiple organizations; thus, virtual teams may be transnational or global and multiorganizational (Gibson and Cohen, 2003, p. 4).

From the perspective of organizations, some advantages of virtual teams include: higher profits, improved access to global markets, environmental benefits (Cascio, 2000), 24/7 productivity by using different time zones of members who are geographically dispersed (Dulebohn and Hoch, 2017), greater flexibility and responsiveness (Hunsaker and Hunsaker, 2008, Piccoli et al., 2004, Powell et al., 2004) as they are based on flat organizational structures without hierarchies and central authority (Jarvempaa and Tanriverdi, 2003), opportunities to reduce travel, relocation (Dulebohn and Hoch, 2017), operating and capital costs (Geister et al., 2006). Additionally, virtual teams may be formed to unify functions across an organization, integrate employees as a result of mergers or acquisitions and increase working opportunities in organizations with an undesirable location (Cascio and Shurygailo, 2003).

From the perspective of employees, they may enjoy the flexibility of accomplishing their tasks from the lo-cation of their preference. Such flexibility may facilitate the balance of employees' work and life and potentially increase their satisfaction with the job.

Consequently, virtual teams can more easily and innovatively respond to the changing requirements of the environment based on the latest knowledge, flexible working arrangements and application of information and communication technologies, making organizations agile and competitive.

1.2 Tools used in virtual teamwork

The continuous development of information and communication technologies have facilitated the creation of new mechanisms for coordinating work and new collaborative organizational forms, business models and working practices (Snellman, 2014, p. 1254).

Virtual tools are defined as modes of communication used by team members to interact virtually, to per-form the functions essential to a standard team (Hertel et al, 2004). There are multiple tools aimed at fulfilling the communicative and working requirements of virtual teams: email, video conferencing, group conferencing platforms, group chat rooms, instant messaging, shared workspaces, online meeting tools, collaborative design tools, knowledge-management systems, social media and other virtual reality options. They all provide auditory and/or visual connections between team members (Bouwman et al, 2008), and some of them offer the opportunity of information sharing.

Nedelko's (2008) study showed video conferencing is a tool that is frequently leveraged in virtual team communication and can optimize performance within the team. Conferencing platforms not only enable multiple participants to communicate simultaneously, but also facilitate: information sharing, negotiating, problem solving and team decision making (Laitinen and Valo, 2018, p. 13). Being able to communicate with immediate feedback represent a basic requirement in virtual team collaboration and instant messaging is a simple and rap-id solution. Another tool that can be used by members of virtual teams is represented by discussion forums based on some specific tasks. These forums provide area for members to communicate and to learn. Social media (social network sites and also virtual environments) is defined as a group of internet-based applications built on the ideological and technical foundation of Web 2.0, which allow creation and exchange of user generated content (Kiesler and Cummings, 2002:61). Social media provides a platform for sharing, discussing, and co-creating knowledge and information (Sigala and Chalkiti, 2015) between virtual team members. Finholt and Sproull stated in 1990 that "virtual team environments not only lack a shared physical setting, but, depending on the technology used, members are also invisible to each other". Nowadays virtual environments eliminate this disadvantage; virtual environments allow users, through their avatars, to participate in modifying the con-tent of rich virtual environment, create objects, move around in a virtual environment and utilize team working-tools (Bosch-Sijtsema and Haapamäkib, 2014, p. 396).

Tools such as Electronic Performance Monitoring systems (EPM) and Team Awareness Systems (TAS) re-port feedback information on the activities and performance of each member of the team. These are conducted to improve the coordination of communication between parties comprising the team (Dabbish and Kraut, 2008). While EPM and TAS are valuable to all teams, virtual teams tend to depend much more on these electronic-based tools than non-virtual teams (Bisbe and Sivabalan, 2017, p. 15).

1.3 Challenges in virtual teamwork

While virtual teams provide a number of advantages to both organizations and team members, there are inherent challenges resulting from team virtuality. Moreover, some studies show that managing virtual teams is more

difficult than managing collocated teams (Hoch and Kozlowski, 2014; Fiol and O'Conner, 2005). Re-searchers have noted that "just bringing people with the required knowledge and skills together virtually provides no guarantee that they will be able to work effectively and innovate across contexts" (Cramton, 2001, p. 452). Consequently, challenges of managing virtual teams have received significant attention in academic literature (Cascio and Shurygailo, 2003; Martins et al, 2004).

Some challenges in working in virtual teams include: diffused roles and responsibilities (Lee-Kelley and San-key, 2008), communication and collaboration difficulties, potentially lower team engagement by team members, difficulties in creating trust and shared responsibility among team members, high levels of social distance between members (Dulebohn and Hoch, 2017, p. 569), differences in salience and interpretation of written texts, the absence of non-verbal communication, more limited set of communication cues conveyed by electronic media (Powell et al, 2004), more scope for opportunistic behaviors and social loafing (Jarvenpaa and Leidner, 1999) and greater difficulty with socio-emotional processes such as relationship building, cohesion and trust (Warkentin et al, 1997).

Further, we will focus on presenting the challenges of using information and communication technologies in virtual teams such as: members' lack of technology experience and/or skills, limited training and support, user unfriendliness to technologies and the cost of technologies.

The first challenge concerns the members' skills to use certain virtual instruments. The new technologically mediated working arrangements require sometimes new skills and team members might not have enough time and/or technical support to learn to use these new tools. New technology that the team is not skilled enough to implement well may completely ruin a team, especially at formation stage (Gibson and Cohen, 2003, p. 250).

Even if team members use known software tools and long implemented within the organization, there are in-evitable and needed upgrades, service packs and new version releases that might reduce the functionality of the virtual team for a certain period of time. Another challenge is that there might be incompatibilities between the tools or versions of the same tools used by team members in order to collaborate.

Choosing the right technology for a virtual team might be also a challenge. Gibson and Cohen (2003, p. 262) suggest that:

- asynchronous communication technologies are appropriate, and may even be the best choice, when tasks are low in complexity;
- synchronous communication technologies are the most appropriate choice for complex tasks that require independent collaboration, such as sense making, problem solving, and decision making.

In addition, a number of researchers have argued that rich media communication (video conferences, for example) is more suitable when sharing knowledge that is of a complex, equivocal nature (Klitmøller and Lauring, 2013, p. 398 after Hayward, 2002 and Kezsbom, 2000). On the other hand, lean media moderates negative team outcomes such as increased conflict and social fragmentation in an intercultural context (Stahl et al, 2010). Also, Pinjani and Palvia (2013, p. 145) stated that effective information and communication technology increases the positive impact of diversity and diminishes the negative effects of cultural diversity.

2 Methods

This study adopted a quantitative approach by means of questionnaire administered online in order to reach the largest possible group of respondents. The results obtained in this way allow us to know the opinion of a given group of respondents on the research topic and to use them to form certain generalizations. The data presented were collected in the two last week of January 2019 from 622 students from two universities: Bialystok University of Technology in Poland (346 respondents) and University of Babeş-Bolyai in Romania (276 respondents). An invitation email containing a link to an online survey was sent to several classes from the bachelor and the master programs of all faculties from both universities. The online survey allowed to collect responses to the dependent measures as well as information on teamwork experience, field and year of study, level of foreign language skills, place of residence, and gender. Of the respondents, females were more numerous than males (66 percent); the students were from the first year of the bachelor programs to the second year of the master programs (M_114,40, SD_123,41). Most of students (43 percent) were from a large city (over 150,000 inhabitants), slightly less of them were from a medium or a small city (35 percent) and the rest (22 percent) were from village (M_155,5, SD_78,35).

Finally, half of students know an English language, and one-third of them know this language at least on intermediate higher level (B2); the half ones know other languages, like German, Russian, Hungarian or French.

The questionnaire was made up of several sections: working in multicultural teams, working in virtual teams and willingness to cooperate in team. The section of working in virtual teams focus on work experience in virtual team, challenges of working in this type of teams, and knowing and using of the tools for virtual teamwork. The questionnaire consists of different kind of questions: yes/no questions (for example: Did you have the chance to participate/work (e.g. at work or in college) in virtual teams?), opened questions (for example: Describe activities you had the opportunity to cooperate in virtual teams), questions with using a 5-point Likert scale (1 = 'strongly disagree' to 5 = 'strongly agree') (for example: What were the main challenges you encountered when working in virtual teams?).

Once data collection were partly finalised, the SPSS statistical software package was used to organise and analyse the data. In the analysis, the descriptive statistics using non-parametric techniques and factor analysis with varimax rotation were conducted.

3 Research results

The respondents were asked about work experience in virtual team which was defined as a team of people working on the implementation of a common goal, in which team members are spatially dispersed, and communication takes place through modern information technologies (e.g. messenger, Skype). Almost the half of the students (48,1 percent) have experience in virtual teamwork and these respondents were taken into account in further analyzes. The respondents were asked about their experience in working in virtual team with using open question. Among describing activities which gave the opportunity to cooperate in virtual teams, students mainly indicate experiences regarding to study such as the preparation of projects or presentations for classes or regarding to professional work:

"Group work at the university, for example creating a presentation in the cloud." (student, female, second year of the bachelor program, Faculty of Engineering Management)
"Preparation of presentations for classes, using Skype, Messenger from Facebook" (student, male, third year of the bachelor program, Faculty of Engineering Management)
"*Implementation of the Best Entrepreneurship Classes competition, cooperation with coordinators from 6 cities in Poland*" (student, female, second year of the bachelor program, Faculty of Engineering Management)
"Completing notes on a virtual disk and solving and consulting exam tasks" (student, male, second year of the bachelor program, Faculty of Engineering Management)
"Professional remote work - mainly marketing agencies" (student, male, second year of the bachelor program, Faculty of Engineering Management)
"Support for social networking sites, creating game programs and projects, solving problematic issues from various fields" (student, male, first year of the bachelor program, Faculty of Electrical Engineering)
"Teleconferences at work regarding cooperation between foreign and Polish branches" (student, female, first year of the bachelor program, Faculty of Engineering Management)

This study provides insight into the most significant challenges that respondents encountered during working in virtual teams. Table 1 presents the principal components analysis of factors that influence virtual teamwork. The data demonstrate adequate internal reliability (Cronbach's alphas 0,847).

The factor analysis of these items leads to the extraction of tree factors which cumulatively explain 72 per-cent of the variance. One of the dimensions of challenges of working in virtual team is insufficient knowledge of IT tools by team members and hardware difficulties (e.g. software, computer, internet access). The other dimensions are related with language skills (the first factor) and with management of this kind of team (the third factor) such as leadership and different skills of team members.

Table 1 The main components of analysis

Factors	1 (language skills)	2 (IT tools and IT skills)	3 (leadership skills)
coordination problems	0,302406	-0,142785	0,741892
lack of involvement, motivation and commitment of team members	0,139944	-0,088242	0,762995
decision making problems	-0,045636	0,316069	0,685824
leadership problems (i.e. delegating, monitoring and providing feedback)	-0,113934	0,445211	0,687835
team roles problems (unclear tasks/roles of each member)	0,017597	0,351942	0,693998
not meeting the deadlines	0,216130	0,014062	0,673704
skill-level differences between members	0,394575	-0,035075	0,670124
personality differences between members	0,529335	0,101205	0,319959
language proficiency difficulties of the members	0,805156	0,279383	0,012101
communication problems	0,573552	0,366293	0,425951
insufficient knowledge of IT tools by team members	0,319501	0,776699	-0,011443
hardware difficulties (software, computer, internet access)	0,154875	0,801817	0,078854

kurtosis -0,4359; coefficient alfa 8,0405

Source: own compilation

From the study point of view is important to obtain the information about respondents' knowledge of IT tools. Thus, the study analyzes the knowing and using the tools of virtual teamwork by students (tab. 2). The most used tools are these which are the most popular among young people: various kinds of messengers, mobile phone, social media like Facebook, e-mail and tool for creating folders and holding files like Google drive – over 76 percent of students use the tools (M_82,5, SD_6,1), at least 7 percent know the tools, but do not use (M_15,4, SD_5,6), and only 2 percent do not know the mentioned tools (M_2,2, SD_1,1).

Next group of tools for virtual creating and sharing documents are also quite well known: between 47 and 53 percent students use tools such as Scribbler, Google Docs and SharePoint, Dropbox; between 28 and 37 percent students know it, but do not use; and between 15 and 18 percent students do not know it. Meetings with using Skype, phone and video are used on average by 34 percent of students; known, but not used by 60 percent; and not known by 6 percent.

The least known and used tools are those which are more advanced such as Yammer or Jive for social networking and Huddle or Blackboard Collaborate for collaboration (used M_4,6, SD_1,1; known, but not used M_25,3, SD_1,9; not known M_70,2, SD_3,0)

Table 2 Types of virtual tools used for teamwork

Factors	'I use'	'I know, but I don't use'	'I don't know'
messenger tools (Facebook Messenger, whatsapp)	91,8%	7,1%	1,2%
mobile phone	84,2%	14,1%	1,6%
social media (Facebook, LinkedIn)	81,9%	14,5%	3,6%
e-mail	78,3%	20,4%	1,3%
Google drive	76,1%	20,8%	3,1%
document cocreation (Scribbler, Google Docs)	53,0%	28,8%	18,3%
document sharing (SharePoint, Dropbox)	47,4%	37,3%	15,3%
Skype meetings	43,1%	53,9%	3,0%
video-conferences	30,8%	61,3%	7,9%
telephoneconferences	29,1%	64,5%	6,4%
project management tools (Microsoft project, Basecamp)	20,0%	32,5%	47,5%
virtual meeting rooms	16,3%	60,2%	23,4%
cloud computing	15,4%	40,2%	44,5%
meeting tools (Google hangouts, GoToMeeting)	13,5%	44,7%	41,8%
3D tools (Second Life, World of Warcraft, Interior Space Design programs)	12,5%	36,3%	51,2%
social networking (Yammer, Jive)	5,3%	26,6%	68,1%
collaboration tools (Huddle, Blackboard Collaborate)	3,8%	23,9%	72,3%

Source: own compilation

Conclusion

To sum up, the research results shows that many students have experience in a virtual teamwork, but half of them do not have such experience. Their experience is mainly regarding with preparing a project or a presentation for classes. Instead of meeting and work together they communicate by virtual tools. Some of students have opportunity to use virtual tool in working. Among the reasons for the difficulty of working in a virtual team, the respondents indicated insufficient knowledge of IT tools by team members and hardware difficulties. Although the use of various virtual tools is quite common, the most popular ones are those that allow to communicate at a distance or allow to share documents.

A practical implication arising from this study is follow. In the context of growing needs in this area, it seems important to conduct classes that will enable to acquire teamwork skills. It seems that the students learn to use virtual tools by the way doing of something for classes. They do not participate in any especially dedicated activities that could prepare them for virtual team work. Thus, the classes should teach students how to use of virtual tools to a greater extent, especially that some of the tools are well known but not used. The same recommendation can be made to organizations that might organize internships in order to familiarize students with IT tools used in virtual teamwork.

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References

ALSHARO, M., GREGG, D., RAMIREZ, R. (2017). Virtual team effectiveness: The role of knowledge sharing and trust. *Information & Management*, 54(4), 479-490. Doi 10.1016/j.im.2016.10.005.

BISBE, J., SIVABALAN, P. (2017). Management control and trust in virtual settings: A case study of a virtual new product development team. *Management Accounting Research*, 37, 12-29. Doi 10.1016/j.mar.2017.02.001.

BOSCH-SIJTSEMA, P.M., HAAPAMÄKI, J. (2014). Perceived enablers of 3D virtual environments for virtual team learning and innovation. *Computers in Human Behavior*, 37, 395-401. Doi 10.1016/j.chb.2014.04.035.

BOUWMAN, H., VAN DEN HOOFF, B., VAN DE WIJNGAERT, L., VAN DIJK, J. (2008). *Information and Communication Technology in Organizations*. London: Sage Publications.

CASCIO, W. (2000). Managing a virtual workplace. *The Academy of Management Executive*, 14(3), 81-90.

CASCIO, W. F., SHURYGAILO, S. (2003), E-Leadership and Virtual Teams. *Organizational Dynamics*, 31(4), 362-367. Doi 10.1016/S0090-2616(02)00130-4.

CRAMTON, C. (2001). The mutual knowledge problem and its consequences in dispersed collaboration. *Organization Science*, 12(3), 346-371.

DABBISH, L., KRAUT, R. (2008). Awareness displays and social motivations for coordinating communication. *Information Systems Reseach*, 19(2), 221-238. Doi 10.1287/isre.1080.0175.

DULEBOHN, J. H., HOCH, J. E. (2017). Virtual teams in organizations. *Human Resource Management Review*, 27(4), 569-574. Doi 10.1016/j.hrmr.2016.12.004.

ESPINOSA, J. A., SLAUGHTER, S. A., KRAUT, R. E., HERBSLEB, J. D. (2007). Familiarity, complexity, and team performance in geographically distributed software development. *Organization Science*, 18 (4), 613-630. Doi 10.1287/orsc.1070.0297.

EUBANKS, D. L., PALANSKI, M., OLABISI, J., JOINSON, A., DOVE, J (2016). Team dynamics in virtual, partially distributed teams: Optimal role fulfilment. *Computers in Human Behavior*, 61, 556-568. Doi 10.1016/j.chb.2016.03.035.

FINHOLT, T., SPROULL, L. S. (1990). Electronic groups at work. *Organization Science*, 1(1), 41-64. Doi 10.1287/orsc.1.1.41.

FIOL, C. M., O'CONNER, E. J. (2005). Identification in face-to-face, hybrid and pure virtual teams: Untangling the contradictions. *Organization Science*, 16(1), 19-32.

GEISTER, S., KONRADT, U., HERTEL, G. (2006). Effects of process feedback on motivation: satisfaction and performance in virtual teams. *Small Group Research*, 37, 459-489. Doi 10.1177/1046496406292337.

GIBSON, C. B., COHEN, S. G. (editors) (2003). *Virtual Teams That Work: Creating Conditions for Virtual Team Effectiveness*. San Francisco: John Wiley & Sons.

GROßER, B., BAUMÖL, U. (2017). Why virtual teams work - State of the art. *Procedia Computer Science*, 121, 297-305. Doi 10.1016/j.procs.2017.11.041.

HERTEL, G., KONRADT, U., ORLIKOWSKI, B. (2004). Managing distance by interdependence: Goal setting, task interdependence, and team-based rewards in virtual teams. *European Journal of Work and Organizational Psychology*, 13(1), 1-28. Doi 10.1080/13594320344000228.

HOCH, J. E., KOZLOWSKI, S. W. J. (2014). Leading virtual teams: Hierarchical leadership, structural supports, and shared leadership. *Journal of Applied Psychology*, 99(3), 390-403. Doi 10.1037/a0030264.

HUNSAKER, P. L., HUNSAKER J. S. (2008). Virtual teams: a leaders' guide. *Team Performance Management*, 14(1/2), 86-99. Doi 10.1108/13527590810860221

JARVEMPAA, S. L., TANRIVERDI, H. (2003). Leading virtual Knowledge Networks. *Organizational Dynamics*, 31(4), 403–412.

JARVENPAA, S., LEIDNER, D. (1999). Communication and trust in global virtual teams. *Organization Science*, 10(6), 791-815.

KIESLER, S. CUMMINGS, J. N. (editors) (2002). *What do we know about proximity and distance in work groups? A legacy of research*. Distributed Work, Boston: MIT Press

KLITMØLLER, A., LAURING, J. (2013). When global virtual teams share knowledge: Media richness, cultural difference and language commonality. *Journal of World Business*, 48(3), 398-406. Doi 10.1016/j.jwb.2012.07.023.

LAITINEN, K., VALO, M. (2018). Meanings of communication technology in virtual team meetings: Framing technology-related interaction. *International Journal of Human-Computer Studies*, 111, 12-22. Doi 10.1016/j.ijhcs.2017.10.012.

LEE-KELLEY, L., SANKEY, T. (2008). Global virtual teams for value creation and project success: a case study. *International Journal of Project Management*, 26(1), 51-62. Doi 10.1016/j.ijproman.2007.08.010.

MALHOTRA, A., MAJCHRZAK, A. (2014). Enhancing performance of geographically distributed teams through targeted use of information and communication technologies. Human Relations, 67(4), 389-411. Doi 10.1177/0018726713495284.

MARTINS, L. L. GILSON, L. L., MAYNARD, M. T. (2004). Virtual teams: What do we know and where do we go from here? *Journal of Management*, 30(6), 805-835. Doi 10.1016/j.jm.2004.05.002.

MATWIEJCZUK W., SAMUL J. (2016). Teamwork measures and organizational performance: some empirical observation. *21th International Scientific Conference: Economics and Management ICEM' 2016*, 57-61.

NEDELKO, Z. (2008). The role and importance of groupware for teamwork. *The Business Review*, 10(1), 211-218.

O'LEARY, M. B., CUMMINGS, J. N. (2007). The spatial, temporal, and configurational characteristics of geographic dispersion in teams. *MIS Quarterly*, 31(3), 433-452. Doi 10.2307/25148802.

PICCOLI, G., POWELL, A., IVES B. (2004). Virtual teams: team control structure, work processes and team effectiveness information. *Technology People*, 17 (4), 359-379. Doi 10.1108/09593840410570258.

PINJANI, P., PALVIA, P. (2013). Trust and Knowledge Sharing in Diverse Global Virtual Teams. *Information & Management*, 50, 144-153.

POWELL, A., PICCOLI, G., IVES, B. (2004). Virtual teams: a review of current literature and directions for future research. *The Data Base for Advances in Information Systems*, 35(1), 6-36. Doi 10.1145/968464.968467.

SCHAUBROECK, J. M., YU, A. (2017). When does virtuality help or hinder teams? Core team characteristics as contingency factors. *Human Resource Management Review*, 27(4), 635–647. Doi 10.1016/j.hrmr.2016.12.009.

SIGALA, M., CHALKITI, K. (2015), Knowledge management, social media and employee creativity. *International Journal of Hospitality Management*, 45, 44-58. Doi 10.1016/j.ijhm.2014.11.003.

SNELLMAN, C. L. (2014). Virtual teams: opportunities and challenges for e-leaders. *Procedia - Social and Behavioral Sciences*, 110, 1251-1261. Doi 10.1016/j.sbspro.2013.12.972.

STAHL, G., MAZNEVSKI, M.L., VOGHT, A., JONSEN K. (2010). Unraveling the effects of cultural diversity in teams: A meta-analysis of research in multicultural work groups. *Journal of International Business Studies*, 41(4), 690-709. Doi 10.1057/jibs.2009.85.

WADSWORTH, M. B., BLANCHARD, A. L (2015). Influence tactics in virtual teams. *Computers in Human Behavior*, 44, 386-393. Doi 10.1016/j.chb.2014.11.026.

WARKENTIN, M. E., SAYEED, L., HIGHTOWER, R. (1997). Virtual teams versus face-to-face teams: An exploratory study of a web-based conference system. *Decision Sciences*, 28(4), 975-996.

Current situation and trends in creating corporate strategy

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Abstract

Purpose of the article In current corporate practice, strategic situation analysis methods fail in generating corporate strategy. Not all analytic tools can be considered suitable and effective. The article presents the results of complex research on business entities in the Czech Republic focused on the area of creating corporate strategy, or the level and anticipated trends in strategic management and decision-making.

Methodology/methods The tested sample included 456 companies from the Czech Republic, further classified by their size (109 micro enterprises, 140 small enterprises, 124 medium-sized companies and 83 companies with more than 250 employees), sector (201 manufacturing and industrial enterprises, 255 companies from the services sector) and location of their business activities (189 regional companies, 126 national companies and 141 multinational companies). By using Pearson´s chi-squared test, dependence / independence of selected internal and external methods of strategic situation analysis on creating corporate strategy are tested.

Scientific aim The objective of the article is to analyze and assess the application of the strategic situation analysis methods in creating a corporate strategy and the corporate sphere top managers awareness of such methods.

Findings The results obtained showed that the application of strategic situation analysis is insufficient and rather schematic. In a number of cases, it was found out that top managers often lack knowledge of basic rules and principles of strategic corporate management.

Conclusions In the period of slowing economic growth, insufficient application of strategic situation analysis methods can be considered a critical element in terms of a company future competitiveness. In the conclusion, the authors present a vision of a new approach in generating corporate strategy based on the industry value chain and new approach to determining and analysis of business environment.

Keywords: strategic situation analysis, corporate strategy, value chain, corporate environment, strategic management and decision-making

JEL Classification: M15, M21

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Introduction

Most of top managers of leading companies in the Czech Republic in personal interviews emphasize the importance and irreplaceability of strategic thinking and decision-making for management and decision-making processes while criticizing the current level of theoretical knowledge in this area. They document failures or ineffectiveness currently used or recommended strategic analytical methods concentrated in so-called strategic situation analysis (SA). These methods are a basis for teaching at universities within the subject Strategic management. The reasons of low efficiency of these methods in generating corporate strategies include constantly intensifying changes in corporate environment, as well as the fundamental changes in economic Framework where the companies conduct their business activities. It can be reasonably assumed that in the period of economic growth that is currently fading out in our economy, the need for generating corporate strategy is reduced in the minds of top managers. However, in terms of the strategic thinking needs and principles it should be reversal. In the period of economics growth it is necessary to design a corporate strategy from the perspective of expected decrease in the economic growth, which can result in a significant competitive advantage for the business entities in the future. The authors of the article had the opportunity to visit a number of such companies person-ally within the framework of a long-term mutual cooperation. The strategic materials prepared by the companies based on this principle were inspiring and motivating for the authors to intensify their research activities to create a new methodology for generating corporate strategy, especially on the basis of a value chain analysis and a new approach to define and analyse corporate environment.

1 Literary research

The concept of strategy dates back to old human history 2500 years ago, the period of Ancient China and Greece, but this was related to the concept of military strategy. The emergence of strategic management as an independent science dates back to the 1960s – 1970s. H. Mintzberg (1990) moves this important date even 10 years back, into the 1950s, in relation with publication of the first work dealing with the explanation of strategy, V.H. Newman´s book, Administrative Action, in 1951. The first book with "strategy" in the sense of strategy related to the behaviour of a business entity (Strategy and Structure) was published in 1962 by Alfred Chandler (Clegg et al., 2011). Since the origins of strategic management as an independence science strategic management theory aimed primarily at systematical conducting of corporate practice has been constantly changing and evolving (Tan and Ding, 2015; Hoskisson et al., 1999). Currently there is no uniform theory that could serve as a base for corporate practice. H. Mintzberg (1990) determined ten basic schools of strategic management in terms of their approach to strategy (Design School, Planning School, Positioning School, Entrepreneurial School, Learning School, Power School, Cognitive School, Cultural School, Environmental School and Configuration School). His work was followed by a number of other authors (Prahalad, Hamel 1990; Whittington, 2001; Mallya, 2007; Vodáček and Vodáčková, 2009; Kourdi, 2009; etc.), who strived for a certain "simplification" and reduction of the approaches generated. As major and most cited strategic management theories can be considered the following ones: positioning theory (Porter, 2012, 2015), internal resources-based theory (Barney, 1991) and knowledge-based theory (Drucker, 1988; Nurmi 1998). Since the later half of the 20th century there have been witnessed intensive efforts to create and conceptualize new approaches and theories, management methods and tools, which are related to the fundamental changes that have taken, or are taking place in the corporate environment in the world, or European economy.

Especially in the last third of the last century it became clear that the used way of managing companies based on the static perception of processes occurring in the market economy, their predictability, repetition and linear progression is, in terms of existing dynamic development in the corporate sphere, unsustainable. It is not incidental that the corporate environment is currently referred to as turbulent, the processes occurring as discontinual; globalization and internationalization processes are taking place with high intensity. The requirements placed on top managers are increasingly higher, especially in terms of their ability to be good strategist and visionaries (Clegg et al., 2011; Andreeva and Kianto, 2016). A new perspective on managerial work, strategic management and decision-making in terms of new economy started to emerge. Corporate strategists should monitor not only the operation of the companies, but also their environment so that they could record the changes and respond to them flexibly with the aim to eliminate negative impacts, particularly as a result of in-creasing competition.

According to the existing strategic theory management, in order to formulate a corporate strategy, a strategic situation analysis is used, which by means of internal and external strategic analyses (analytical tools), analyses and evaluates the internal and external company environment. Want (2007) states that for each analytical tool, its expected contribution should be clearly defined, and the application of analytical tools is often based on the

cooperation with external business entities and is usually financially and time consuming. Downey (2007) states that all analytical tools are based on historic, past data that extrapolate the future assumptions. He points out that in interpreting the results it is necessary to be careful, since the results can be influenced by prejudices or pressures arising from the company. Frost (2003) describes that the tools and management tools support strategic thinking of managers and reduce the risks associated with the decision-making. Knott (2006) has a similar opinion, claiming that the role and tasks of strategic management tools and techniques form a basis for strategic thinking, and are a starting point for structuring strategic management activities.

The most widely used analytic tool is a SWOT analysis, which is a very popular tool not only in the Czech Republic but also among organizations in Great Britain (Gunn and Williams, 2007) or Australian companies (Frost 2003), then customer satisfaction analysis, Porter´s five forces model, PEST analysis, benchmarking and portfolio analysis methods. These methods are used by more than 50 % of business entities, as Gunn and Williams (2007) say. Abdulhussien and Hamza (2012), Williams and Naumann (2011) emphasize the value chain analysis and benchmarking, since these can reduce costs, improve product quality and evaluate a company performance.

The beginning of the 21st century means an important moment in the strategic management as a scientific field. Creating corporate strategies based on the principle of analytic strategic methods for the internal and external environment started to fail in the corporate sphere. A crucial stage in approaching the situation analysis methods were the works of Porter (2012, 2015), who claimed that a corporate strategy does not depend on the ability to predict changes. However, what is important is a detailed awareness on which groups of customers and which needs will be dominant in the following three and five years. The same author also admits that a good analysis is of a crucial importance; in his opinion, however, it is not reasonable to create a corporate strategy in advance, since finding a really good strategy suitable for a company is a matter of several years (Magretta, 2012). Abraham, (2012) and Duggan, (2007) mention the differences between the analytical approach and creating a strategy. An important moment in terms of creating a corporate strategy was a publication of Michael Perter´s work, Competitive Advantage, in 1985. He specified the importance of the value chain, which is defined by Porter as a powerful tool that allows dividing a business into strategically important activities resulting in higher prices or lower costs (Magretta, 2012). Many other authors, such as Hill and Jones (2001), Robbins and Coulter (2004), Mallya (2007), Blažková (2007), Zuzák (2011), Feller et al. (2006), Weele, (2009) etc. deal with a value chain concept.

The authors of the article respect and do not diminish the importance of strategic situation analysis when evaluating the internal and external corporate environment. The value chain analysis, including the analysis of the internal industry structure, however, considered principal in generating unique and original value chains of the individual business entities. Only a corporate strategy created this way can provide the company with the required competitiveness and sustainability in the newly emerging geographic and economic framework of the world, Europe, region or municipality.

2 Material and methods

The research was carried out on the sample of 456 companies in the Czech Republic. The sample included 109 micro companies, 140 small companies (up to 50 employees), 124 medium-sized companies (up to 250 employees) and 83 large companies (above 250 companies). The prevailing presence of small and medium-sized companies in the sample corresponds with the typical structure in the Czech Republic, for which small and medium-sized companies are characteristic. The companies were further classified according to the industry sectors in the Czech Republic - production and industrial companies (201 companies) and service sector companies, but also by the location of their business activities into regional (189), national (126) and multinational (141) companies.

Two hypotheses were formulated:

- H1: Situation analysis is in Czech corporate practice intensively used for projection of corporate strategy and development priority-setting.
- H2: Top managers´ command of methods for internal and external environment analysis is sufficient for their implementation, evaluation and subsequent implementation of the results obtained into corporate practice.

In terms of statistical methods, Pearson´s chi-square test to identify the dependence / independence of selected category variables (internal and external strategic analysis) was used to create a corporate strategy. The formula for Pearson´s chi-square independence test is as follows:

$$x^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(n_{ij} - e_{ij})^2}{e_{ij}} \quad (1)$$

X^2 chi-square

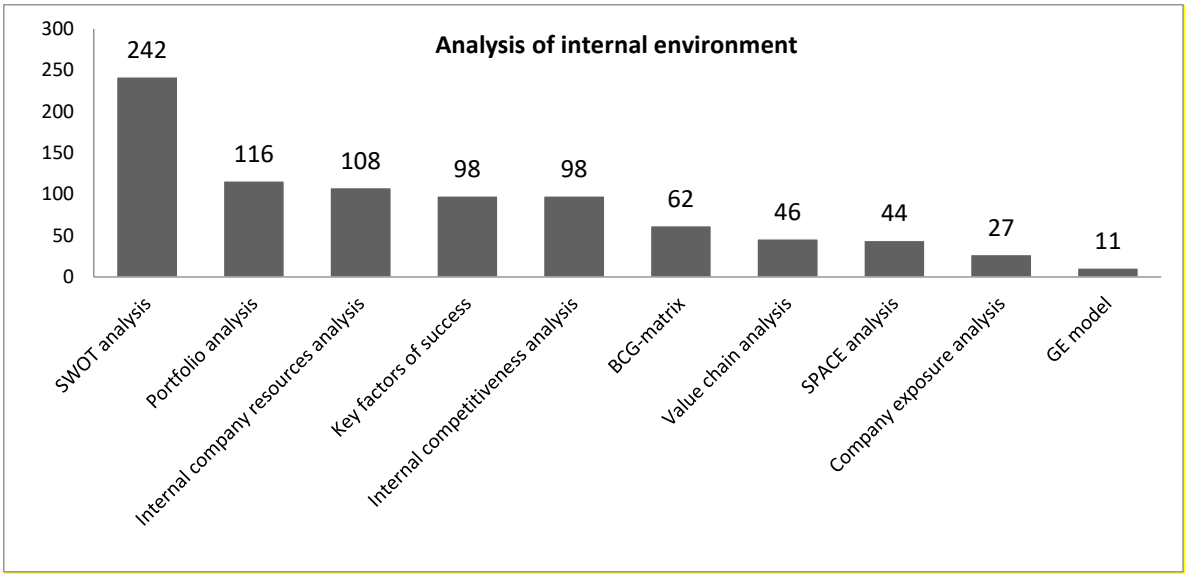
X_i empirical frequency (actual)

N_{pi} theoretical frequency (expected)

In the tests, two hypotheses are assumed, null (H_0) and alternative (H_A). H_0 (no dependence between the selected features), H_A (dependence between the selected features). The evaluation criterion for verification of rejection of the hypothesis is p-value, whose values are in the interval <0,1>. If the resulting p-value < α (with the fixed significance level α= 0.05), H_A is verified.

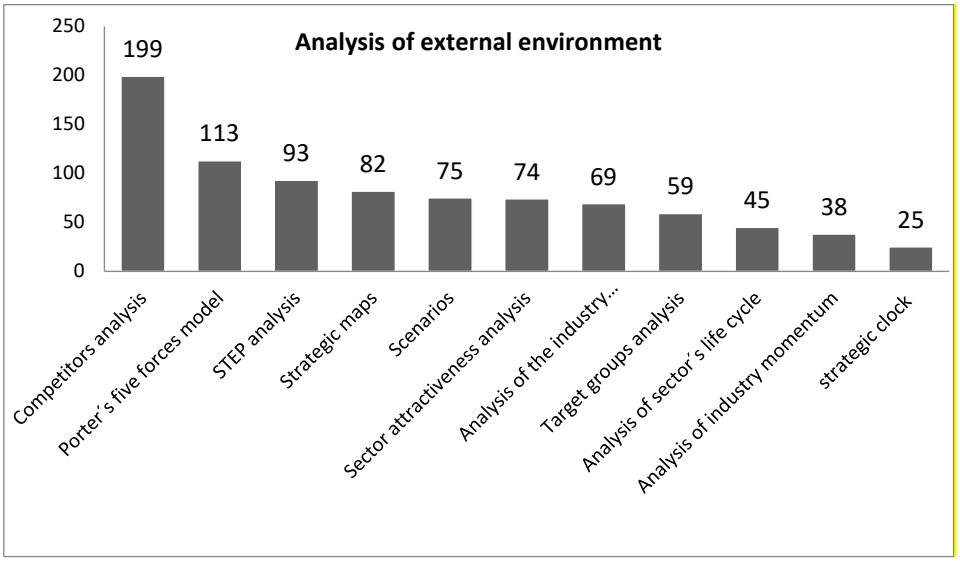
3 Discussion

The following graphs show the frequency of applying strategic situation analysis methods divided in methods for internal environment analysis (internal strategic analysis) and external environment analysis (external strategic analysis).



Source: Own research

Figure 1 Frequency of using strategic situation analysis methods for evaluating the internal company environment



Source: Own research

Figure 2 Frequency of using strategic situation analysis for evaluation of external corporate environment

It results from Graph 1 that within the Czech Republic corporate sphere internal environment analysis, the most frequent one is the SWOT method, then portfolio analysis and internal company resources analysis. In terms of analysing the external company environment (Figure 2), the most frequently used method is the competitors analysis, analysis of sector´s internal structure – Porter´s five forces model, and STEP analysis. The results point to the fact that more than 50 % of the companies tested does not use any of the strategic methods. In this relation, a question arises on what basis and using what methods and procedures the strategic materials are processed and what determines the decision-making of company managers. Interviews with top managers of leading companies, especially in the South Bohemian region, indicate the growing need to create an appropriate methodical and practical procedure for generating corporate strategy. The need for this procedure is enhanced by the need to provide company managers with adequate information for their relevant strategic planning and decision-making in their day-to-day management practice.

Table 1 Dependence of generating corporate strategy on company sector, size and location of business activities in internal analyses

Analysis	Sector (p.value)	Company size (p.value)	location of activity (p.value)
SWOT analysis	0.8921	0.4663	0.4305
Portfolio analysis	0.3586	0.8461	0.1377
Internal company resources analysis	0,3162	0.4976	0.5966
Key factors of success	0.9874	0.1927	0.2976
Internal competitiveness analysis	0.3086	0.4195	0.9636
BCG-matrix	0.871	0.4078	0.9106
Value chain analysis	**0.008428**	0.1927	0.6386
SPACE analysis	0.913	0.3004	0.887
Company exposure analysis	0.6613	0.9451	0.3936
GE model	0.6139	0.7167	0.5219

Source: own research

The results in Table 1 confirm the dependency of only one analysis – value chain analysis in terms of sector classification of the tested companies. This finding is fully inline with the corporate strategy generating theory, which states that value chain is one of the key elements for creating a successful corporate strategy. Other internal analyses showed no statistically significant values, both in terms of size and location of the activities of the companies tested. These results include, inter alia, the reflection of a gradual change in globalization processes that are giving way to national, regional and local specifics. Gradually, the geographical form of the world economy map, new economic centers appear (China, India, etc.) while the competitive tension grows on the world markets. It is not possible to identify a set of key factors for internal company environment applicable to all three assessment plans. What is very positive is highlighting the role of value chain for strategic management and decision-making, which is a significant qualitative step forward in the managers´ awareness.

Table 2 Dependence of preparing corporate strategy on sector, size and location of business activities of company in external analyses

Analysis	Sector (p.value)	Company size (p.value)	location of activity (p.value)
Competitors analysis	0.6514	0.1242	0.5069
Analysis of competition in the sector (Porter´s five forces model)	0.7713	0.671	0.6984
STEP analysis	0.8112	0.3615	0.1917
Strategic maps	0.198	0.437	0.7463
Scenarios (prediction of company external environment development)	0.429	0.6221	0.8786
Analysis of sector attractivity	0.1391	0.8971	0.903
Analysis of sector´s economic characteristics	0.935	0.7879	0.2913
Analysis of target groups	0.8808	**0.04944**	0.9808
Analysis of industry´s life cycle	0.5083	0.4595	0.1912
Industry momentum analysis	0.4083	**0.01219**	0.09801
Strategic clock	0.8145	0.3031	0.2803

Source: Own research

Table 2 shows the overview of external strategic analyses dependence on creating a corporate strategy in terms of the sector, size and location of the activities of the companies tested. Statistically important values have been indicated for two external analyses (analysis of target groups and industry momentum analysis), but only in terms of size category of the tested companies; lower dependence can be seen only for industry momentum analysis for the category of location of company activities. What is interesting is the lack of Porter´s five forces model, or analysis of the industry internal structure, which is considered to be a very important one in terms of theory and absolutely necessary in terms of generating corporate strategy. This result can be partially influenced by the fact that the research was carried out in the period of strong economic growth. This fact does not necessarily mean that the tested companies did not consider the key factors determining the internal industry structure, but that they were not given particular attention to.

Conclusion

Based on the results of the research, the authors cannot make a final and comprehensive conclusion on the issue solved. Nevertheless, they can describe the current situation in the corporate sphere in terms of the existing level and forms of strategic management and decision-making and predict the expected development in this area.

Creation of a corporate strategy has assumed a theoretical knowledge and practical application of strategic methods for analysing internal and external company environment. However, the results have confirmed the authors´ assumption that nearly a half of the companies tested do not use any of the strategic situation analysis methods.

This statement rejected the first hypothesis. A question therefore arises on what basis and using what methods and procedures the strategic materials are processed, especially in terms of medium-sized and large companies. The top managers were also identified a lower level of knowledge in strategic management and decision-making, especially in the case of companies based outside the Czech Republic, thus rejecting the second hypothesis.

In internal strategic analyses, the dependence on creating corporate strategy was demonstrated only for the value chain analysis, in terms of the sector category, which is a very positive finding especially in terms of the future development and the need to provide an effective tool for generating successful, competitive corporate strategies. In the case of the world´s most widely used SWOT analysis, the dependence has not been proved. Emphasizing the role of the value chain for strategic management and decision-making can be considered a significant qualitative step forward in the minds of top managers. This fundamental change can be justified also by growing dominance of new economic relations and links within the global economic system.

External analyses showed the dependence on processing the corporate strategy in terms of size of the companies tested, mainly in the case of target groups analyses and industry momentum analysis. A surprising and unexpected finding is the absence of internal industry structure analysis (Porter´s five forces model).

Based on the aforementioned conclusion it can be stated that the fundamental changes are necessary in the area of using strategic situation analysis methods in corporate practice. Besides the alarming lack of knowledge of theoretical foundations and practical skills in strategic management and decision-making, top managers have more frequently bring up a question of their effectiveness and efficiency. The research of the article´s authors showed that it is appropriate to analyse the company environment in its integral form, that is, in balance and integrity of its sub-components (external and internal corporate environment), as well as the value chain. The application of a newly created value chain analysis method the authors of the article are currently working on can be considered a prospective procedure when generating an original and unique competitive strategy of the given company. The negative findings described in the article in terms of methods and tools for generating corporate strategy are intended not only for top managers in the corporate sphere, but it is also a topical challenge for research organizations, including universities.

References

ABDULHUSSIEN, H. M., HAMZA, S. (2012). Strategic Management Accounting Techniques in Romanian Companies: An Empirical Study. *Studies in Business and Economics*, 7(2), 126-140.

ABRAHAM, S. C. (2012). *Strategic planning: a practical guide for competitive success*. 2nd ed. Bingley: Emerald Group Pub Ltd.

ANDREEVA, T., KIANTO, A. (2016). Empirically Testing the Role of Strategic Management of Knowledge in Firm Performance. In: MOFFETT, S. et al. (eds.). *Proceedings of the 17th European Conference on Knowledge Management* (1-8). Coleraine, UK: Academic Conferences Ltd.

BARNEY, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99-120.

BLAŽKOVÁ, M. (2007). *Marketingové řízení a plánování pro malé a střední firmy*. [Marketing management and planning for small and medium companies] Praha: Grada Publishing.

CLEGG, S.ET al. (2011). *Strategy. Theory and Practice*. London: SAGE Publication Ltd..

DOWNEY, J. (2007). *Strategic Analysis Tools. CIMA Global*. London: Jim Downey and Technical Information Service. Retrieved from: http://www.cimaglobal.com/Documents/ImportedDocuments/cid_tg_strategic_analysis_tools_nov07.pdf.pdf

DRUCKER, P. F. (1988). The Coming of the New Organization. *Harvard Business Review*, 66(1), 45-53.

DUGGAN, W. R. (2007). *Strategic intuition: the creative spark in human achievement*. New York: Columbia Business School Pub.

FELLER, A., SHUNK, D., CALLARMAN, T. (2006). *Value Chains Versus Supply Chains*. BPTrends. Retrieved from: http://www.bptrends.com/bpt/wp-content/publicationfiles/03-06-ART-ValueChains-SupplyChains-Feller.pdf

FROST, F A. (2003). The use of strategic tools by small and medium-sized enterprises: an Australasian study. *Strategic Change*, 12(1), 49-62. Doi 10.1002/jsc.607

GUNN, R., WILLIAMS, W. (2007). Strategic tools: an empirical investigation into strategy in practice in the UK. *Strategic Change Journal*, 16(5), 201–216.

HILL, CH. W. L., JONES, G. R. (2009). *Essentials of strategic management*. 2nd ed. Mason: South-Western/Cengage Learning.

HOSKISSON, R. E., HITT, M. A., WAN, W. P., YIU, D. (1999). Theory and Research in Strategic Management: Swings of a Pendulum. *Journal of Management*, 25(3), 417-456.

KNOTT, P. (2006). A typology of strategy tool applications. *Management Decision*, 44(8), 1090-1105. Doi 10.1108/00251740610690630

KOURDI, J. (2009). *Business Strategy: A Guide to Taking Your Business Forward*. ISBN 978-18-4668-1240. Retrieved from: https://www.host.ebsco.com/

MAGRETTA, J. (2012). *Michael Porter jasně a srozumitelně*. [Michael Porter brightly and clearly] Praha: Management Press. ISBN 978-80-7261-251-2.

MALLYA, T. (2007). *Základy strategického řízení a rozhodování*. [Fundamentals of strategic management and decision-making] Praha: Grada Publishing.

MINTZBERG, H. (1990). The design school: Reconsidering the basic premises of strategic management. *Strategic Management Journal*, 11(3), 171-195. Doi 10.1002/smj.4250110302

NURMI, R. (1998). Knowledge-Intensive Firms. *Business Horizons*, 41(3), 26-32. Doi 10.1016/S0007-6813(98)90005-2

PORTER, M. E. (1985). *Competitive advantage: creating and sustaining superior performance*. New York: Free Press. ISBN 0029250900

PORTER, M. E. (2012). Recent Developments in Competitiveness and Strategy. *Porter Prize Conference*, Hitotsubashi University. Graduate School of International Corporate Strategy, Tokyo, Japan.

PORTER, M. E. (2015). Shared Value and Strategy. *Paper presented at the Shared Value Leadership Summit, FSG*, New York, NY.

PRAHALAD, C. K., HAMEL, G. (1990). The Core Competence of the Organization. *Harvard Business Review*, 68(3), 79-91.

ROBBINS, S. P., COULTER, M. (2004). Management. Praha: Grada Publishing. ISBN 80-247-0495-1.

TAN, L., DING, J. (2015). The frontier and evolution of the strategic management theory: A scientometric analysis of Strategic Management Journal, 2001-2012. *Nankai Business Review International*, 6(1), 20-41. Doi 10.1108/NBRI-09-2014-0036

VODÁČEK, L., VODÁČKOVÁ, O. (2009). *Moderní management v teorii a praxi*. [Modern management in theory and praxis] Praha: Management Press.

WANG, G. (2007). Research on business environment of construction supervison in China. In: *CRIOCM2007 International Research Symposium on Advancement of Construction Management and Real Estate*, 649-659.

WEELE, A. J. (2009). *Purchasing and Supply Chain Management: Analysis, Strategy, Planning and Practice*. UK: Cengage Learning EMEA.

WHITTINGTON, R. (2001). *What is strategy – and does it matter?* London: Thomson Learning.

WILLIAMS, P., NAUMANN, E. (2011). Customer satisfaction and business performance: a firm-level analysis. *Journal of Services Marketing*, 25(1), 20-32. Doi 10.1108/08876041111107032.

ZUZÁK, R. (2011). *Strategické řízení podniku*. [Corporate Strategic Management] Praha: Grada Publishing.

Value Creation Process for Digital Business and Entrepreneurship: New Challenges for Human Intellectual Capital in the digital World

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Abstract

Purpose of the article To find tools and methods to research how value creation can be done using smart data and what kind o business models shall be used for implementation these new models into digital business.

Methodology/methods We propose an approach to analyse the current situation with using intellectual capital in digital innovation companies.

Scientific aim This methodology puts in evidence several examples of successful profiting from using of intellectual capital in the frame of current digital economics. The business models of predigital companies, based on promoting products, have also evolved. Their offer has gradually shifted towards services, to such an extent that what they are selling is not so much the product as the functions it serves.

Findings Value creation in digital innovation companies can be viewed as a system of three interacting components. First, the domain choice, selecting where to compete. Second, the resource base in terms of individual and collective knowledge. These two components provide input in terms of the demand of customers and the capabilities in the resource base of the company, to the third component: the product or service delivery process (PSDP). The content of the PSDPs can vary according to the needs of the customer.

Conclusions The outcomes of the application can be used in business environment for the new innovative companies working in digital business (IT-technologies, Big Data applications etc.).

Keywords: data, value proposition design, business model design, value creation, intellectual capital

JEL Classification: M15, M21

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Introduction

Digital entrepreneurship as a relevant socio-economic and technological phenomenon, which can be considered as the joining of traditional entrepreneurship with an emphasis on leveraging new digital technologies in novel ways, such as social, mobile, analytics, cloud and cyber-solutions, all in order to shift the traditional way of creating and doing business in the digital era.

Digital Entrepreneurship can be defined as embracing "new ventures and the transformation of existing business by creating and using novel digital technologies. Digital Enterprises are characterised by a high intensity of utilisation of new digital technologies (particularly social, mobile, analytics and cloud solutions) to improve business operations, invent new (digital) business models, sharpen business intelligence, and engage with customers and stakeholders through new (digital) channels". However, it is important to stress that there is a difference between 'digital entrepreneurship' and 'digital business' in general and 'digital start-ups' and 'digital scale-ups', which we believe provides an additional perspective.

Moreover, the 'digital' component relates to what Parker et al. (2016) refer to as 'digital platforms' that "consummate matches among producers and consumers and facilitate the exchange of goods, services or social currency, enabling value creation for all through the digital landscape". Hence, digital start- ups and scale-ups are ventures that incorporate novel digital technology as a vital component of their business model and which could not feasibly operate without the internet-enabled platforms. This would therefore include businesses working on the 'Internet of Things (IoT)', and online retailers such as Amazon, but exclude retailers who have a physical presence on the high street.

2 Assessment of Knowledge Capital and Intellectual Assets

The worth of knowledge assets, taking the difference between market and book values as a proxy, is hidden by current accounting and reporting practices. However, as evident from current valuations of many Net-based enterprises, one observes a significant widening gap between the values of enterprises stated in corporate balance sheets and investors' assessment of those values. The increasing proportion of intangible vis-à-vis tangible assets for most industrial sectors has been affirmed by various other observations (Edvinsson and Malone, 1997; Hope and Hope, 1997; Stewart, 1995). In case of major corporations, often such high market valuations are attributed to brands. Recent business history has shown that huge investments in human capital and information technology are the key tools of value creation that often do not show up on company balance sheets as positive values themselves.

Measurement of institutional or organizational value in the current business environment using traditional accounting methods is increasingly inadequate and often irrelevant to real value in today's economy. For instance, while traditional accounting practices often treat brand as depreciable entity over time, in today's economy, intangible assets like brands and trademarks often increase in value over time, often longer than the time periods accounted for their depreciation. Even, specific kinds of valuations of intellectual capital, such as patents, copyrights and trademarks are not valued according to their potential value in use, but recorded at registration cost. Similarly, the distinction between assets and expenses is made arbitrarily on many balance sheets: an advertising campaign could be recorded in either column as evident from a case such as that of AOL. The traditional balance sheet, a legacy of last five centuries of accounting practices, provides a picture of historic costs, assuming that the cost of purchase reflects the actual value of the asset. However, it does not account for the hidden value inherent in people's skill, expertise and learning capabilities, the value in the network of relation-ships among individuals and organizations or the structural aspects relevant to servicing the customers. These hidden values or intangible assets assume increasingly important role in an economy that is characterized by a transition from 'programmed' best practices to 'paradigm shifts' that characterize the new business world of 're-everything' (Malhotra, 2000). Such factors are assuming greater importance in assessment of the potential for future growth of an enterprise or a national economy.

This issue is compounded by an apparent paradox: the more a company invests in its future, the lesser is its book value [although the recent astronomical caps for various Net-related stocks suggest increasing realization about intangible assets]. Extrapolating the case of such companies to the organizations within a national economy, one may understand the implications for accounting for intangible assets that do not show up in accounting reports, but may underpin their future success or failure.

Valuation from the perspective of intellectual capital and knowledge assets takes into consideration not only financial factors, but also human and structural factors (Stewart, 1997). Stewart defines intellectual capital as the

intellectual material that has been formalized, captured, and leveraged to create wealth by producing a higher-valued asset. Intellectual capital is defined as encompassing: i) human capital; ii) structural capital; and iii) relational capital. These aspects of intellectual capital include such factors as strong business relationships within networked partnerships, enduring customer loyalty, and employee knowledge and competencies. The compelling reasons for valuation and measurement of intellectual capital and knowledge assets include under-standing where value lies in the company and the sectors of the national economy and for developing metrics for assessing success and growth of companies and economies.

3 Measuring Knowledge Assets and Intellectual Capital

Managers of enterprises and national economies are trying to find reliable ways for measuring knowledge assets to understand how they relate to future performance. The expectation from finding reliable measures of knowledge assets is that such measures can help managers to better manage the intangible resources that increasingly determine the success of the enterprises and economies.

The terms knowledge capital and intellectual capital are used synonymously in this article. Within the scope of subsequent discussion, such terms refer to "the potentiality of value as it exists in various components or flows of overall "capital" in a firm; the relationships and synergistic modulations that can augment the value of that capital; and the application of its potential to real business tasks… [it] includes an organization's unrefined knowledge assets as well as wealth generating assets whose main component is knowledge" (Society of Management Accountants of Canada 1999, p. 17).

One may observe that it is the application of intellectual capital to practical situations that contributes, primarily, to the translation of its potential value to financial assets. Or as observed by Stewart (1997, p. 67): "Intelligence becomes an asset when some useful order is created out of free-floating brainpower – that is, when it is given coherent form (a mailing list, a database, an agenda for a meeting, a description of a process); when it is captured in a way that allows it to be described, shared, and exploited; and when it can be deployed to do some-thing that could not be done if it remained scattered around like so many coins in a gutter." Unless effectively utilized and applied, knowledge assets may not necessarily yield any returns in terms of financial performance measures. In other words, "knowledge assets, like money or equipment, exist and are worth cultivating only in the context of strategy… you cannot define and manage intellectual assets unless you know what you are trying to do with them" (Stewart 1997).

The subsequent discussion reviews the case of an Asian nation state that utilized one of the more popular methods for assessment of its national intellectual capital. Concluding discussion will highlight the existing caveats in the adopted methodology and underscore the important issues that need to be addressed in future research and practice.

4 The Innovation Capability Model

As was stated (Lerro, Linzalone and Schiuma, 2009) that Innovation Capability Model assumes that company's performance is based on the results of the innovation which, in turn, is primarily dependent of the innovation sources. Innovation capability itself, then, is not a separately identifiable construct. A holistic model of in-novation capability will thus attract debate about categorization of pillars and elements, but it is a necessary step in order to facilitate analysis and construction of an innovation framework. The pillars and elements have been built up from the literature on innovation management as well as best practice and specific studies of innovative firms.

The following pillars are proposed to exist within innovative companies. They are strategy, innovation sources, innovation capacity, and innovation process and innovation results. The innovation capability will lead to continuous products, process and system innovation. The stronger innovation capability possessed by a company, the more effective will be its performance and value creation. The core pillars of innovation capability, as well as their major elements. Are discussed in detail in the next sections:

4.1 Strategy

The link between strategy and innovation is important to effective innovation management. This is a critical step in institutionalizing innovation, creating a vision, a target which if achieved will create products that outperform and provide a distinct market position. The success of companies breaking the rules of their industries through innovation and become a dominant player has been well-documented (Hamel, 1998; Kim and Mauborgne, 1999; Markides, 19997).

4.2 Innovation sources

Competitive pressure and rapid growth of ICT have forced companies to review the sources of their innovation performance and value creation dynamics. The concept of knowledge has emerged a strategically significant resource for the firm (Grant, 1996; Mintzberg et al., 1976) and has been asserted to play a significant role in innovation process (Song and Montoya-Weiss, 1998).

4.3 Innovation capacity

In this model, innovation resources nurture innovation capability. The innovation capability enables integration and transformation of resources to develop potential innovation that can be transferred into companies` processes through the leverage of their knowledge base (Cohen and Levinthal, 1990). The cross-functional integration and co-operation of organizational capabilities are at basis of "innovation capacity". In fact, in line with Lawson and Samson (2001) statements, the "innovation capacity" can be interpreted as the organizational ability to mould, integrate and manage multiple resources and capabilities of the firm to successfully stimulate in-novation.

4.4 Innovation processes

Traditionally, process research addresses the nature of the innovation process, how and why innovations emerge and grow. In this model, process has come to be conceived as a temporal, path-dependent phenomenon (King, 1992; Koput, 1997; Schroeder et al, 1989) that is a collection of tasks or activities and an integration and exploitation of organizational capabilities which together transform inputs into outputs. Successful innovation requires an optimal overall formal business structure (Burgelman and Maidique, 1988). The nature of the innovation process has been shown to be affected by a range of factors such as organizational structure (Burns and Stalker, 1961; Daft, 1978; Holbek, 1988), environmental factors (Tidd, 2001), technology management. The management of technology is critical for all kinds of organizations. Innovative companies are able to effectively link their core technology strategies with the innovation strategy and business strategy.

4.5 Innovation outputs and company's value creation

Innovation makes to competitive advantage (Tidd, 2001). This output has generally been construed in terms of financial, market or organizational performance. Output performance research focuses intently on the role of novelty or newness as a factor of successes, although results are not completely shared (Avlonitis et al, 2001, Tidd, 2001). According to a value based approach (Neely et al, 2002), superior innovation performance mean major value created for company's key stakeholders.

5 Value Creation in the Digital World

The significant developments in digital network and communication technologies has led to the emergence of digital business (Bharadwaj et al., 2013). Organizations then started to scramble to develop new business strategies that align with their business objectives. But continued advancements in technology have enabled new dynamic organizational capabilities as well as transformed social structures and relationships (Bharadwaj et al., 2013). For this reason, it has been suggested that it is becoming increasingly difficult to separate digital products from IT infrastructure. New forms of organizing emerge due to the confluence between IT and organizational capabilities resulting in new affordances for creating value in organizations (Zammuto et al., 2007). Bharadwaj et al. (2013) argued that this perceived inseparability compels rethinking the traditional business-IT strategy alignment view and instead move towards their fusion in digital business strategies.

They defined digital business strategy as "organizational strategy formulated and executed by leveraging digital resources to create differential value". One of the four pillars of their conceptualization of digital business strategy is the sources of business value creation and capture. In digital business, organizations continue to leverage IT infrastructures to create new sources of value creation and sustainable competitive advantage (Kohli and Grover, 2008; Yoo et al., 2010). Information is one key source for value creation. There is established recognition of increased value from information by using IT (Bharadwaj et al., 2013; Kohli and Grover, 2008). IT has enabled significant transformation in the ways information is created, exchanged, shared, remixed, and redistributed which in turn caused dramatic power shifts in market channels and disruption of traditional sources of economic profits. These transformations, Bharadwaj et al. (2013) argued, have created fundamentally new sources of value. This can be seen in digitization processes through which new combinations of resources result in novel product and service innovations. The encoding of analog information into digital format like in many contemporary newspapers

that are shifting from physical creation and distribution of content into the digital arena is an example of the creation of new innovative digital sources of value. The shift into digitized information at Newsweek magazine, for instance, shows how the magazine started to explore new sources of value creation by balancing between subscription and advertising (Bharadwaj et al., 2013).

Digital mobile platforms like Apple's iOS, Google's Android, and Amazon's Kindle are important examples of how the digitization of products and services has created new ecosystems of value that redefined the entrainment, music, and book publishing industries. In this respect, Yoo et al. (2010) discussed several new digital strategy frameworks to capture new sources of value creation in such marketplaces such as generativity, heterogeneity, creating digital product platforms and meaning-making capabilities. Besides information-based value creation, there is also the integration of IT in physical artifacts. Yoo et al. (2010) discussed another dimension of value creation with IT. They explained that the value of IT lies in its integration with and expansion towards third-party components. They argued that the increasing embedding of digital components into physical products has created novel layered modular architectures.

An example of this was reported by Svahn et al. (2009) where they discussed the integration of service-based modularity into component-based modularity within the car infotainment industry. This kind of integration creates new forms of digital materiality which leads to the "emergence of digital service architecture for previously non-digital products and services" (Yoo et al., p. 14). Clearly, such innovative architectures have the potential to enable novel sources for value creation and competitive advantage for both organizations and developers.

6 Conclusions

In this paper, we synthesized the value creation perspective (Schumpeter, 1934; Moran and Goshal, 1996), and digital platforms literature (Ghazawneh and Henfridsson 2013; Tiwana et al. 2010; West 2003) to study the value creation in digital application marketplaces. Based on an extensive research study of third-party developers (Amit, and Zott, 2001; Bharadwa et al, 2013; Mansour, 2017; Pagani, 2013) we developed an empirically grounded understanding of value creation where we identified six value sources that are combined and ex-changed to create values that can be realized by third-party developers.

Future studies could address several limitations in our work. It would be useful to compare our results with investigations of third-party developers from other countries. Another direction for future work would be to investigate value creation, and also potential value destruction, in digital application marketplaces from the perspective of users and owners of digital platforms.

References

ANDERSON, O., KHEAM L S. (1998). Resource-Based Theory and International Growth Strategies: an Exploratory Study. *International Business Review*, 7, 163-184.

AMIT, R., AND ZOTT, C. (2001). Value Creation in E-Business. *Strategic Management Journal*, (22), 493-520.

AVLONITIS, G. J., PAPASTATHOPOULOU, P.G., GOUNARIS, S. P. (2001). An empirically based typology of product innovativeness for new financial services: success and failure scenarios. *Journal of Product Innovation Management*, 18(5), 324-342

BARNEY, J. B. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17(1), 99-120.

BHARADWAJ, A., EL SAWY, O., PAVLOU, P., VENKATRAMAN, N. (2013). Digital Business Strategy: Toward a next generation of insights. *Management Information Systems Quarterly*, 37(2), 471-482.

BURGELMAN, R. A., MAIDIQUE, M. A. (1988). *Strategic Management of Technology and Innovation*. Irwin, Homewood, Illinois

BURNS, T. R., STALKER, G. M. (1961). *The Management of Innovation*. Tavistock Publications, London

CARLUCCI, D., MARR, B., SCHIUMA G. (2000). The knowledge value chain: How Intellectual Capital Impacts on Business Performance. *International Journal of Technology Management*, 27(6/7), 575-587

COHEN, J., LEVINTHAL, D. A. (1990). Absorptive capacity: A new perspective of learning and innovation. *Administrative Science Quarterly*, 35(1), 554-571

DAFT, R. (1978). A dual-core model of organizational innovation. *Academy of Management Journal*, 212(2), 193-210.

DAVENPORT, T. H., PRUSAK, L. (1998). *Working knowledge: How organizations manage what they know*. Harvard Business School Press, Boston.

EDQUIST, C., HOMMEN, L. McKELVEY, M. (2002). *Innovation and Employment: Process versus Product Innovation*. Edward Elgar, London

EDVINSSON, L., MALONE, M. S. (1997). *Intellectual Capital*. Harper Collins, New York.

GRANT, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17, 109-122.

HAMEL, G. (1998). Strategy innovation and the quest for value. *Sloan Management Review*, 7-14.

HOLBEK, J. (1988). The innovation design dilemma: some notes on its relevance and solutions. In: GRØNHAUG, K., KAUFMANN, G. (Eds.) *Innovation: a cross disciplinary perspective*. Norwegian University Press, 253-277.

HOPE, J., HOPE, T. (1997). *Competing in the Third Wave*. Harvard Business School Press, Boston, MA.

KIM, W. C., MAUBORGNE, R. (1999). Strategy, value innovation and the knowledge economy. *Sloan Management Review*, 40(3), 41-54.

KING, N. (1992). Modeling the innovation process: an empirical comparison of approaches. *Journal of Occupational and Organizational Psychology*, 65(2), 89-100.

KOHLI, R., GROVER, V. (2008). Business value of IT: An essay on expanding research directions to keep up with the times. *Journal of the Association for Information Systems*, 9(1), 23-39.

KOPUT, K. (1997). A chaotic model of innovative search: some answers, many questions. *Organization Science*, 8(5), 528-542.

LAWSON, B., SAMSON, D. (2001). Developing innovation capability in organizations: a dynamic capabilities approach. *International Journal of Innovation Management*, 5(3), 377-400.

LERRO, A., LINZALONE, R. SCHIUMA, G. (2009). Modeling Organizational Innovation Capability: a Knowledge-Based Approach. *Proceedings of the IV International Forum on Knowledge Assets Dynamics Intellectual Capital Management and Innovation Capability*, 17-18 February, Glasgow, Scotland, UK

LI, HONG BIN, MENG, L., ZHANG, J. (2006). Why Do Entrepreneurs Enter Politics? Evidence from China. *Economic Inquiry*, 44(3), 559-578.

MALHOTRA, Y. (2000). Knowledge Management for E-Business Performance: Advancing Information Strategy to Internet Time. *Information Strategy: The Executive's Journal*, 16(4), 5-16.

Mansour O., GHAZAWNEH A., (2017). Value creation in digital service platforms. *Proceedings Australasien Conference on Informations Systems*, Hobart, Australia

MARKIDES, C. (1997). Strategic innovation. *Sloan Management Review*, 9-23.

MARR, B., SCHIUMA, G. (2001). Measuring and Managing Intellectual Capital and Knowledge Assets in New Economy Organisations. in Handbook of Performance Measurement, ed. M. Bourne, Gee, London.

MARR, B., SCHIUMA, G., NEELY, A. (2004). Intellectual Capital – defining key performance indicators for organizational knowledge assets. *Business Process Management Journal*, 10(5), 551-569.

MINTZBERG, H., RAISINGHANI, D., THEORET, A. (1976). The structure of unstructured decision processes. *Administrative Science Quarterly*, 21(2), 246-275.

NEELY, A., ADAMS, C., KENNERLEY, M. (2002). *The Performance Prism*. Financial Times Prentice Hall, London.

OSNOS, E. (2009). *Beijing's crash program for clean energy*. New Yorker.

PAGANI, M. (2013). Digital Business Strategy and Value Creation: Framing the Dynamic Cycle of Control Points. *MIS Quartely*, 37(2), 617-632.

SCHIUMA, G., ORDÓÑEZ DE PABLOS, P., SPENCER, J. C. (2007). Foreword: Intellectual Capital and company's value creation dynamics. *International Journal Leaning and Intellectual Capital*, 4(4), 331-341.

SCHROEDER, R. G., VAN DE VEN, A. H., SCUDDER, G. D., POLLEY, D. (1989). The development of innovation ideas. in: VAN DE VEN, A. H., ANGLE, H. L., POOLE, M. (Eds) *Research on the management of innovation: the Minnesota studies*, 107-133, Harper & Row, New York.

SONG, X. M., MONTOYA-WEISS, M. M. (1998). Critical development activities for really new versus incremental products. *Journal of Production Innovation Management*, 15(2), 124-135.

SPENCER, J.W, MURTHA, T. P., LENWAY, S. A. (2005). How Governments Matter to New Industry Creation, Academy of Management. *The Academy of Management Review*, 30(2), 321.

STEWART, T. (1997). *Intellectual Capital: The New Wealth of Organizations*. Doubleday: New York.

STEWART, T. (1995). Trying to Grasp the Intangible. *Fortune*, 2.

SVAHN, F., HENFRIDSSON, O., YOO, Y. (2009). A Threesome Dance of Agency: Mangling the Sociomateriality of Technological Regimes in Digital Innovation. *Proceedings of the 30th International Conference on Information Systems*, Phoenix, USA, December 15 – 18.

TANICHEV, A. (2009) Using Long Cycles Theory for Mastering Growth Strategy. *Proceedings International Scientific Conference Insights into the Sustainable Growth of Business*, 19-21 November, Vilnius, Lithuania

TANICHEV, A. (2010). Networking as a Key Factor for Successful Implementation of Innovations (Comprehensive Analysis of Russian and European Experience). *Proceedings of International Conference for Entrepreneurship, Innovation and Regional Development "Entrepreneurship beyond crisis – channeling changes for advantage*.

TIDD, J. (2001). Innovation management in context: environment, organizational and performance. *International Journal of Management Reviews*, 3(3), 169-183

WEIR, et al (2009). Managing Knowledge Assets in Renewable Energy Industry: Defining a Research Agenda for Scotland's SME`s. *Proceedings of the 5th EIASM Workshop on Visualing, Measuring and Managing and Intangibles and Intellectual Capital*, 7-8 October, Dresden, Germany

YANG, K. (2002). Double entrepreneurship in China's economic reform: An analytical framework. *Journal of Political and Military Sociology*, 30(1), 134-148.

YOO Y., HENFRIDSSON O., LYYTINEN K. (2010). The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, 21(4), 724-735.

YOO Y., BOLAND JR, R.J., LYYTINEN, K., MAJCHRZAK, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, 23(5), 1398-1408

ZAMUTTO, R. G., GRIFFITH, T. L., MAJCHRZAK, A., DOUGHERTY, D. J., FARAJ, S. (2007). Information technology and the changing fabric of organization. *Organization Science*, 18(5), 749-762.

The digital Transformation in Supply Chain

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Abstract

Purpose of the article The purpose of the study is to explore executives' attitudes towards the use of trends and technologies in supply chain.

Methodology/methods A primary survey conducted in May 2018-September 2018 to 204 to supply chain management executives in North-Eastern Greece. A Principal Component Analysis (PCA) with varimax rotation conducted to identify the main factors that affect executives' attitudes towards the use of digital trends and the technologies in supply chain. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) value was checked to be suitable for factor analysis. Chi-square value for Bartlett's test of sphericity was also checked. Regression analysis indicated which the main characteristics are. For all the analysis the statistical package SPSS 22 was used.

Scientific aim The aim is to investigate whether companies are overlooking emerging opportunities, such as those in supply chains. This may influence companies for resource reallocation and strategically shift resources to create more value and deliver higher returns to shareholders.

Findings Executives' attitudes towards the use of trends and technologies such as elastic, cost-to-serve, autonomous road transportation, mobility, IoT, Robotics, in supply chain are affected by the type of company, year of establishment, number of employees, technological infrastructure. The main factors revealed in regression analysis are mobility, human factor and pricing.

Conclusions The supply chain world has transformed fairly quickly over the last few decades. The low rate of supply-chain digitisation to date has much to do with the capabilities of the technologies that companies have available. This preliminary research could not be considered as an indicative for generalization of results. The sample of respondents is only from one part of Greece. Enlargement and reopening of the investigation in future years will record more accurately the views of executives in order to provide safer conclusions.

Keywords: supply chain, digital transformation, chi-square, Principal components analysis, Regression analysis

JEL Classification: M15, M21

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1 Introduction

Industry 4.0 is not limited to the technical dimension of digitalizing modern businesses, as it is rather the complete new organization and network coordination of value and supply chains (Glas and Kleemann, 2016). Industry 4.0 is expected to form in its ultimate shape new digitalized supply chains, which shall realize collaborative productivity rents and ensure no less than the competitiveness of entire industries (Willems, Agrell, and Lejeune, 2018). Whilst many more companies are already investigating how to react to the current trend of implementing Industry 4.0 technologies and concepts, recent research with respect to this term is highly diverse and limited to the operational implementation of technologies and concepts on the production process-level (Herman, Pentek and Otto, 2015).

For a number of industry sectors (retail, auto, electronic, aviation, chemical), digitalization of supply networks has been an important issue for more than two decades, but this concern is not shared across other industries (Hartmann, King and Narayanan, 2015). Digital transformation can have a major impact on all parties across the supply chain. It can negatively impact the supply of materials from manufacturing plants through to the customers, as well as alter the flow of money (Alicke, Rachor and Seyfert, 2016). Unfortunately, the cause of the disruption often goes unexposed until the repercussions actually occur. By then it may be too late to account for the changes that should have happened to prevent the disruption. This can lead to major financial problems, such as a devastating loss of revenue (Baxter, 2016).

The management needs to evaluate how their supply chain will be impacted by the relevant technologies, i.e. which challenges and potentials are to be expected with respect to the primary supply chain activities (Lambert, 2008). With the global supply chain poised to make dramatic shifts in the coming years to accommodate trends and gain deeper visibility into business processes in order to stay ahead of the competitive curve, every company throughout the value chain stands to benefit by adopting new technologies early and rethinking traditional, outdated processes to combat industry disruptors (Pontius, 2017).

According to McKinsey research, digitization has only begun to transform many industries (McKinsey Special Collection Digital strategy, 2017). Digital is penetrating all sectors, but to varying degrees (Bughin, LaBerge and Mellbye, 2017). The perception of respondents for the digital penetration by industry is 44% for travel, transport and logistics. Only 2 percent, in fact, report that supply chains are the focus of their forward-looking digital strategies, though headlining examples such as Airbnb and Uber demonstrate the power of tapping previously inaccessible sources of supply and bringing them to market.

The benefits of Digital supply chain (DSC) include cost-effectiveness of services and value-creating activities that are advantageous to many actors in the ecosystem, including firms and their suppliers, employees and customers (Maier, Passiante and Zhang, 2011). According to Mentzer et al. (2001), a supply chain can be defined as a set of three or more entities (i.e., organizations or individuals) directly involved in the upstream and down-stream flows of products, services, finance, and/or information from a source to a customer.

Supply chain management (SCM) encompasses the efforts involved in delivering and producing products and services in the value chain (Sherer, 2005). SCM links the processes across supplier–user companies and functions that enable the value chain to make products and provide services to the customer (Cox, Blackstone, & Spencer, 1995).

A study by The Boston Consulting Group shows that the leaders in digital supply chain management are enjoying increases in product availability of up to 10 percentage points, more than 25% faster response times to changes in market demand, and 30% better realization of working-capital reductions, on average, than the laggards (Korn Ferry Institute, 2018). They have 40% to 110% higher operating margins and 17% to 64% fewer cash conversion days. With the help of three key strategies, these agile companies are quickly leaving behind their less nimble competitors. The general consensus is that companies cannot afford to wait and the leaders in digital supply chain management are building a financial advantage that will be more difficult to overcome with each passing year. Companies will need to map opportunities for each of the newly available technologies. With digital transformation changing markets everywhere, top executives around the world are changing their priorities. Korn Ferry International surveyed 100 senior supply chain executives, along with interviewing academics and consultants, to explore issues that leaders face and their approach to building and organising the required talent to support this transformation. More than half of the respondents (53 percent) had a formal position to lead digital SCM, with most (92 percent) reporting to a Chief Operating Officer (COO), Chief Supply Chain Officer (CSCO), or to a supply chain leadership member. Digitisation is highly relevant for SCM, with three-quarters (74 percent)

of executives rating this as 4 or 5 out of 5. Three out of four respondents said their organisations lack a clearly defined success profile for digital transformation of supply chain leaders, with many leaders suggesting that "we don't know how to improve our level of digitisation in supply chain".

McKinsey observes that most of the disparity between potential and actual gains from supply chain digitisation can be explained by technology gaps and poor management choices (McKinsey Special Collection Digital strategy, 2017). However, now that better digital solutions have become available, companies can make greater and faster improvements in supply-chain performance (Gezgin, Huang, Samal and Silva, 2017). According to Supply Chain Digital, 70 percent of executives have already begun digital supply chain transformation, yet progress is slow.

Capgemini Consulting and GT Nexus studied 337 executives from major global manufacturing and retail organizations across 20 countries throughout Europe and North America (Capgemini and GT Nexus, 2017). Exploring the relationship between organizations and their partners throughout the supply chain in their study, they remark that the first to examine both the current and future states of digital transformation across the sup-ply chain. The survey found that half of the executives responding view digital transformation as very important (75 percent agree that digital transformation is at least 'important'), but more than 30 percent are dissatisfied with their progress to date. Just 15 percent of respondents to the survey indicate that data from the extended supply chain is readily available to their organizations, yet 54 percent expect improvements in availability within the next five years (Pontius, 2017).

So, it is useful reading for most procurement people, particularly anyone in those sectors where supply chain is key, and it paints a picture of unmet need really in terms of the skills and talent available in this field. Three quarters of the 100 supply chain executives who participated in the study (through a survey and interviews) acknowledged that digitisation is highly relevant to their situation (KPMG, 2018). As the report says, "The function is expected to develop greater flexibility, lower cost and risk, and even develop new ways of analysing its potential revenue impact". But about four in 10 of those surveyed (41 percent) said a key barrier to digitising the supply chain was the availability of digital talent. Despite this, the "financial commitment to developing the required skills is low", with two thirds of executives saying that less than 10% of training budgets is relevant to digital, and that this amount is clearly not enough. Three-quarters of the sample positioned themselves in the middle of the pack, saying that a start has been made on digitisation, but there was still some way to go, with the "lack of a clear strategy" the biggest barrier to digital transformation. Lack of digital talent was a close second - that fits with our own thinking on general procurement transformation, where clarity of strategy has to come first, and then the "people aspects" really are the most critical success factor (Smith, 2018).

Traditional players in the logistics industry risk becoming irrelevant unless they embrace change in order to deliver more customer-centric services (Brightmore, 2018). DSC examines the findings of a new report by Accenture, which offers businesses advice on how to upgrade digital logistics strategies, calling on companies to raise their game and prepare to disrupt (Morley, 2017). However, according to the report by Accenture on digital disruption in freight and logistics, if traditional players embrace digital adoption and harness the power of new technologies to build new digital business models, they could not only enhance their competitiveness, but also boost earnings by approximately 13% per annum (Accenture, 2017).

The aim of this study is to find out whether there is a relationship between the business digitalization and the supply chain, technology systems or other company features.

2 Methodology

In order to ascertain the views of experts on the digital transformation in supply chain, the views of 204 supply chain management executives in the area of Northern Greece were recorded and processed. However, the respondents are executives who are responsible for SCM functions (i.e. Chief Supply Chain Officers) or executives whose responsibilities explicitly include SCM or indirectly, who had acquired SCM experience in their previous positions. 57.8% of the companies belong to production sector, 4.4% to packing sector, 20.1% to retail sale sector and 17.6% to distribution sector. 13.7% of the companies have less than 10 employees, 28.4% up to 30 employees, 33.8% up to 50 employees, 14.2% up to 200 employees and 8.8% have more than 200 employees.

In order to achieve this goal, we composed a questionnaire for the purpose of collecting empirical data from companies in the region selected for the research. The questionnaire consists of four (4) sections of questions, each of which were matched with company features and views on the digital transformation of the company. The questionnaire is structured since it has a strict order of questions.

Questionnaire consists of 43 items. In section A there are 6 items about company information. In section B there are 14 items about incidence of certain supply chain management issues, in section C (ICT items) there are 11 items about technology systems that have been adopted by each company and in section D there are 12 items about digitalization. All items in sections B, C and D are in 5 point Likert scale where 1 corresponds to "not adopted at all" and 5 to "fully adopted". Since the aim of the study is to find out whether there is a relationship between the digital business and the supply chain, technology systems or other company features, the 12 items in D sector measure the digitalization.

In order to identify patterns in the relationships between the items in section B, a principal component analysis (PCA) was conducted on the 14 items with orthogonal rotation (Varimax). During the analysis, in sequential steps we drop out items 4 and 7 because in the first of them the maximum component value in the corresponding table was 0.373, while in the second the maximum value of the component in the corresponding table was 0.343. The Kaiser-Meyer-Olkin measure verified the sample adequacy for the analysis, (KMO=0.802, Bartlett's test of sphericity $X^2(66)=1249.757$, $p<0.001$), indicated that correlations between items were sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data. Two components had eigenvalues over Kaiser's criterion of 1 and in combination explained 68,178% of the variance. The scree plot showed inflexion that justify retaining of 2 two components in the final analysis.

Finally, the items that cluster on the same components suggested that the first factor represent A-Incoming components and second factor represents B-outcoming components. Incoming denotes activities related to the input of the company while outcoming denotes activities related to the output of the company.

Subsequently, we create a new factor for each one of the above components, as the average value of the items that consists them. These factors are called A-Incoming and B-Outcoming. In order to check about validity and reliability of each one of these two new factors, we use Cronbach's A index. The value of Cronbach's A for factor A is 0.873 and for factor B 0.768, which means that each factor is high reliable, in the sense of internal consistency.

In section C (ICT items), respondents should state whether 11 technology systems have been adopted by their company. These technology systems are presented in table 1. For each one of the technology systems they have to choose between 1 (not adopted at all) to 5 (fully adopted). We generate a new variable that expresses the degree to which each company has adopted technology systems. For this purpose, we added the 11 independent items and we create a new variable, named technology systems adoption, with possible values between 11 and 55. The mean value of this new variable is 35.06 (standard deviation 9.9) and median 34.5.

Table 1 Technology systems that may have been adopted by each company

	Technology system
1	Supply Chain Management (SCM)
2	Customer Relationship Management (CRM)
3	Partner Relationship Management (PRM)
4	Enterprise Resource Planning (ERP)
5	Warehouse Management Systems (WMS)
6	Manufacturing Execution Systems (MES)
7	Transportation Management Systems (TMS)
8	Radio Frequency (RF) systems
9	Geo-coded Tracking
10	Bar coding technology
11	Electronic Commerce Technology

Source: Own research

The digitalization of the company is expressed by 12 items about supply chain in section D. In order to identify patterns in the relationships between these items a principal component analysis (PCA) was conducted on the 14 items with orthogonal rotation (Varimax). During the analysis, in sequential steps we drop out items 7, 10 and 11 because in the first of them the maximum component value in the corresponding table was 0.373, while in the second the maximum value of the component in the corresponding table was 0.343. The Kaiser-Meyer-Olkin measure verified the sample adequacy for the analysis (KMO=0.802, Bartlett's test of sphericity $X^2(66)=1249.757$, $p<0.001$) indicated that correlations between items were sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data. Two components had eigenvalues over Kaiser's criterion of 1 and in combination explained 68,178% of the variance. The scree plot showed inflexion that justify retaining of 2 two components in the final analysis.

In repetive steps we drop out items because in the first item, the Measure of Sampling Adequacy value in the Anti-image Matrix was very low (0.436) and the maximum value of the component value in the corresponding table was 0.386, while in the second item the maximum value of the component in the corresponding table was 0.381.

In order to identify patterns in the relationships between these items, a principal component analysis (PCA) was conducted on the 12 items with orthogonal rotation (Varimax). During the analysis, in sequential steps we drop out items 6, 7 and 11 because in the first one the value of Measure of Sampling Adequacy in the Anti-image Matrix was very low (0.422) and the maximum component value in the corresponding table was 0.386, while in the other two the maximum value of the component in the corresponding table was 0.381 and 0.401. The Kaiser-Meyer-Olkin measure verified the sample adequacy for the analysis, KMO=0.762, Bartlett's test of Sphericity $X^2(36)=348.919$, $p<0.001$, indicated that correlations between items were sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data. Three components had eigenvalues over Kaiser's criterion of 1 and in combination explained 58.958% of the variance. The scree plot showed inflexion that justify retaining of 2 two components in the final analysis.

Finally, the items that cluster on the same components suggested that the first component represents mobility, the second one represents human factor and the third component represents pricing. Items that consist each one of the three components are presented in table 2.

Table 2 Items that consist mobility, human factor and pricing components

	Item
1	Warehouse Robotics in the Supply Chain
2	Increased Focus on Cost-to-serve
3	More Things Will Connect to the IoT
4	Autonomous Road Transportation
5	The Appeal of Supply Chain Social Responsibility
6	The Rise of the Virtual Logistics Team
7	Elastic is the New Lean
8	The Blurred Line Between Logistics and Technology Services
9	Enterprise Mobility Penetration into the Supply Chain

Source: Own research

Subsequently, we create a new variable for each one of the above components, as the average value of the items that consists them. These variables are called mobility, human factor and pricing.

Then, we test whether each of the three factors that constitutes digital business, that is mobility, human factor and pricing, is affected by the sector in which companies operate, the number of employees, the way the supply chain is managed, the degree of adoption of technology systems, incoming and outcoming. This is checked with three multiple regression models. To control the sector in which companies operate, the number of employees and how

supply chain is managed, dummy variables have been created. More specifically in our sample, the companies come from four sectors, production, packing, retail and delivery and the way they man-aged the supply chain has four categories, no management at all, empirically, department of the company and is outsourced. The variable "number of employees" has five values, that is less than 10 employees, between 11 and 30 employees, between 31 and 50 employees, between 51 and 200 employees and more than 200 employees.

3 Results

In this section we present the results of the regression analysis for the three dependent variables.

Dependent variable mobility

In the first regression model, we use mobility as dependent variable. From the final model we excluded the A variable because it was found to be not significant at 5% level (t-statistic = -0.599, p-value = 0.55). The model that will be adjusted is:

$$Mobility = b_0 + b_1 \times technology\ systems\ adoption + b_2 \times B + b_3 \times retail + b_4 \times packing + b_5 \times distribution + b_6 \times no\ management + b_7 \times empirical\ management + b_8 \times department\ of\ the\ company$$

Checking for collinearity was done through the VIF test. All VIF values are lower than 5, so we can safely conclude that collinearity is not a problem for our model. The value of Durbin-Watson test is 1.601, very close to value 2 so is satisfied the condition of independent errors. Regression is significant at 5% (F(8.199) = 15.915, p-value < 0.001). Test for normal error distribution (Normal Probability Plot) showed that errors follow the normal distribution (diagram 1). Test for stable variance of the residuals showed that there is steady variation (diagram 2).

The final model is:

$$Mobility = 4.074 + 0.028 \times technology\ systems\ adoption - 0.521 \times B - 0.439 \times retail + 0.262 \times packing - 0.374 \times distribution + 1.346 \times no\ management - 0.450 \times empirical\ management - 0.043 \times department\ of\ the\ company$$

The coefficients of this model are presented in table 3.

We notice that:

i. For each unit growth of technology_systems_adoption, mobility increases by 0.028 units.

ii. Retail and distribution companies have a lower average of mobility than those involved in the production.

iii. Increasing the score on factor B (Outcoming) leads to a decrease in the average mobility.

iv. Companies that do not manage the supply chain are more mobile than those outsourced, while those who managed supply chain empirically, have lower mobility than outsourced.

Table 3 The coefficients of the model with mobility as dependent variable

	Unstandardized Coefficients				Collinearity Statistics	
	B	Std. Error	t	Sig.	Tolerance	VIF
(Constant)	4.074	.335	12.162	.000		
Technology_systems_adoption	.028	.006	4.675	.000	.721	1.387
B-Outcoming	-.521	.075	-6.928	.000	.933	1.072
Retail sales	-.439	.137	-3.213	.002	.820	1.220
Packing	.262	.251	1.046	.297	.921	1.086
Distribution	-.374	.144	-2.593	.010	.892	1.121
Minimum management of supply chain	1.346	.425	3.169	.002	.705	1.418
Empirical management	-.450	.198	-2.278	.024	.265	3.778
Management Department of the company	-.043	.189	-.228	.820	.278	3.596

Source: Own research

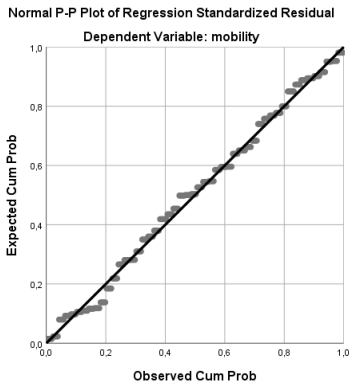

Diagram 1 Normal Probability Plot for mobility

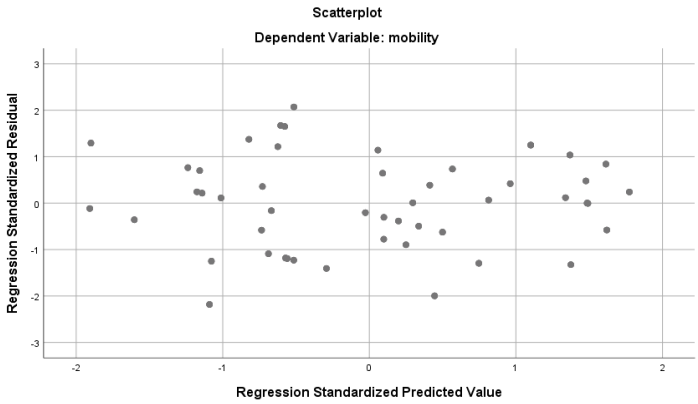

Diagram 2 Test for stable variance of the residuals for mobility

Dependent variable human factor

In the second regression model we use human factor as dependent variable. From the final model we excluded the A variable because it was found to be not significant at 5% level (t-statistic = 1.259, p-value = 0.21). The model that will be adjusted is:

$$Human\ factor = b_0 + b_1 \times technology\ systems\ adoption + b_2 \times B + b_3 \times retail + b_4 \times packing + b_5 \times distribution + b_6 \times (employees < 10) + b_7 \times (employees\ 11 - 30) + b_8 \times (employees\ 31 - 50) + b_9 \times (employees\ 51 - 200) + b_{10} \times empirically\ management$$

Checking for collinearity was done through the VIF test. All VIF values are lower than 5, so we can safely conclude that collinearity is not a problem for our model. The value of Durbin-Watson test is 1.762, very close to value 2 so is satisfied the condition of independent errors. Regression is significant at 5% (F(10.199) = 29.674, p-value < 0.001). Test for normal error distribution (Normal Probability Plot) showed that errors follow the normal distribution (diagram 3). Test for stable variance of the residuals showed that there is steady variation (diagram 4).

The final model is:

$$Human\ factor = 4.252 + 0.018 \times technology\ systems\ adoption - 0.409 \times B - 0.796 \times retail + 0.007 \times packing - 0.239 \times distribution - 0.839(employees < 10) - 0.547 \times (employees\ 11 - 30) - 0.323 \times (employees\ 31 - 50) + 0.100 \times (employees\ 51 - 200) + 0.212 \times empirically\ management$$

The coefficients of this model are presented in table 4.

We notice that:

i. For each unit growth of technology_systems_adoption, human factor increases by 0.018 units.

ii. Retail and distribution companies have a lower average of human factor than those involved in the production.

iii. Increasing the score on factor B leads to a decrease in the average human factor.

iv. Companies that manage empirically the supply chain have higher score in human factor than all other companies.

v. Companies that have less than 50 employees have lower score in human factor than these companies with more than 200 employees.

Table 4 The coefficients of the model with human factor as dependent variable

	Unstandardized Coefficients				Collinearity Statistics	
	B	Std. Error	t	Sig.	Tolerance	VIF
(Constant)	4.252	.291	14.637	.000		
Technology_systems_adoption	.018	.004	4.520	.000	.563	1.776
B-Outcoming	-.409	.052	-7.875	.000	.654	1.529
Retail sales	.007	.158	.045	.964	.772	1.296
Packing	-.796	.083	-9.631	.000	.747	1.338
Distribution	-.239	.090	-2.652	.009	.763	1.311
Employees <10	-.839	.173	-4.839	.000	.230	4.349
Employees 11-30	-.546	.143	-3.827	.000	.315	3.173
Employees 31-50	-.323	.125	-2.593	.010	.237	4.216
Employees 51-200	.100	.153	.652	.515	.326	3.071
Empirical management	.212	.067	3.172	.002	.775	1.290

Source: Own research

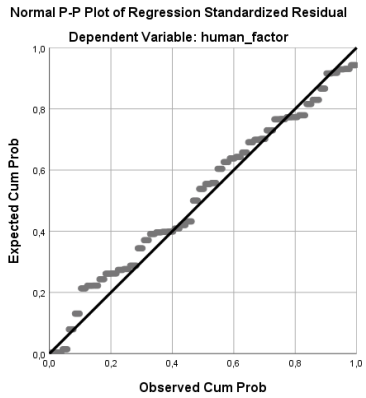

Diagram 3 Normal Probability Plot for human factor

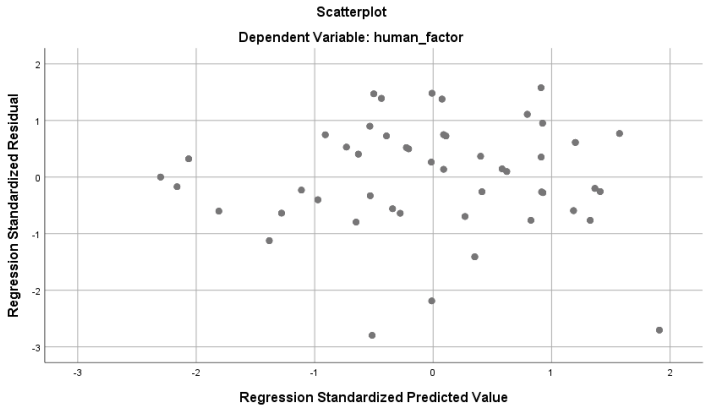

Diagram 4 Test for stable variance of the residuals for human factor

Dependent variable pricing

In the third regression model we use pricing as dependent variable. From the final model we excluded the A variable and the dummy variables related to the number of employees because they were found to be not significant at 5% level. The model that will be adjusted is:

$$Pricing = b_0 + b_1 \times no\ management\ of\ supply\ chain + b_2 \times empirically\ management + b_3 \times department\ of\ the\ company + b_4 \times packing + b_5 \times retail\ sales + b_6 \times distribution + b_7 \times B + b_8 \times technology\ systems\ adoption$$

Checking for collinearity was done through the VIF test. All VIF values are lower than 5, so we can safely conclude that collinearity is not a problem for our model. The value of Durbin-Watson test is 1.804, very close to value 2 so is satisfied the condition of independent errors. Regression is significant at 5% ($F(8,199) = 9.718$, p-value < 0.001). Test for normal error distribution (Normal Probability Plot) showed that errors follow the normal distribution (diagram 5). Test for stable variance of the residuals showed that there is steady variation (diagram 6).

The final model is:

$$Pricing = 2.014 + 1.356 \times no\ management\ of\ supply\ chain - 0.049 \times empirically\ management - 0.023 \times department\ of\ the\ company + 0.728 \times packing - 0.478 \times retail\ sales + 0.571 \times distribution - 0.213 \times B + 0.033 \times technology\ systems\ adoption$$

The coefficients of this model are presented in table 5.

We notice that:

i. For each unit growth of technology_systems_adoption, pricing increases by 0.033 units.

ii. Packing and distribution companies have a higher average of pricing than those involved in the production.

iii. Increasing the score on factor B (outcoming) leads to a decrease in the average pricing.

iv. Companies that do not manage the supply chain have higher score in pricing than companies that use outsource.

Table 5 The coefficients of the model with pricing as dependent variable

	Unstandardized Coefficients				Collinearity Statistics	
	B	Std. Error	t	Sig.	Tolerance	VIF
(Constant)	2.014	.338	5.960	.000		
Minimum management of supply chain	1.356	.413	3.284	.001	.705	1.418
Empirically management	-.049	.192	-.256	.798	.265	3.778
Management Department of the company	-.023	.184	-.124	.901	.278	3.596
Packing	.728	.133	5.483	.000	.552	1.811
Retail sales	-.478	.260	-1.842	.067	.813	1.229
Distribution	.571	.172	3.313	.001	.591	1.693
B-Outcoming	-.213	.073	-2.918	.004	.933	1.072
Technology_systems_adoption	.033	.006	5.778	.000	.721	1.387

Source: Own research

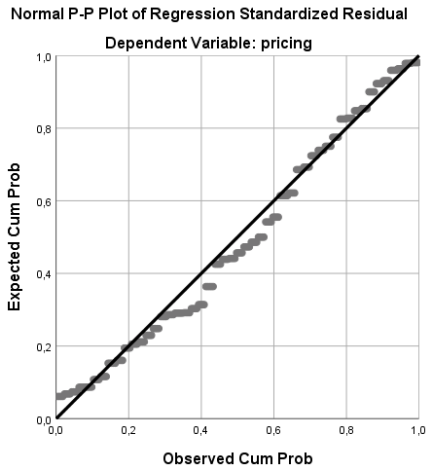

Diagram 5 Normal Probability Plot for pricing

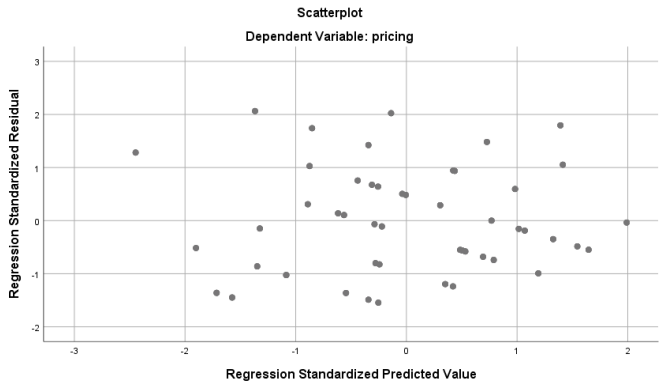

Diagram 6 Test for stable variance of the residuals for pricing

4 Discussion and conclusions

This study explored the supply chain management executives' attitudes towards the use of trends and technologies in supply chain. Executives' attitudes towards the use of trends and technologies such as elastic, cost-to-serve, autonomous road transportation, mobility, IoT, Robotics, in supply chain are affected by the type of company, year of establishment, number of employees, technological infrastructure. The main factors revealed in regression analysis are mobility, human factor and pricing. The findings may influence companies for re-source reallocation and strategically shift resources to create more value and deliver higher returns to shareholders.

The supply chain world, in relative terms, has transformed fairly quickly over the last few decades. Globalization, industry 4.0, the Internet and technological advancement have been the driving forces in manufacturing. The transportation industry has been a little slower to evolve. The low rate of supply-chain digitisation to date has much to do with the capabilities of the technologies that companies have had available until recently. While the

transition to digital supply chains is complex, failure to act now will put your company at a severe disadvantage in the future.

Digital capabilities are critical to meeting the challenge of digital transformation successfully. Incumbents need to consider and drive this rotation to the new as a conscious and deliberate act of renewing and transforming their core business, while growing into new businesses and services.

This preliminary research could not be considered as an indicative for generalization of results. The sample of respondents is only from one part of Greece. Enlargement and reopening of the investigation in future years will record more accurately the views of executives in order to provide safer conclusions.

References

ACCENTURE. (2017). *Digital disruption in freight and logistics. Ready to roll?* Retrieved from https://www.accenture.com/t00010101T000000Z__w__/gb-en/_acnmedia/PDF-53/Accenture-Digital-Disruption-Freight-Logistics.pdf.

ALICKE, K., RACHOR, J., SEYFERT, A. (2016). *Supply Chain 4.0—the next-generation digital supply chain*. Retrieved from https://www. mckinsey. com/business-functions/operations/our-insights/supply-chain-40--the-nextgeneration-digital-supply-chain.

BAXTER, D. (2016). *By Supply Chain Disruption: The Bad, The Ugly, & The Future, Real-Time Visibility*. Retrieved from https://www.supplychain247.com/article/supply_chain_disruption_the_bad_the_ugly_the_future

BRIGHTMORE, D. (2018). *How companies can embrace digital disruption*. Retrieved from https://www.supplychaindigital.com/technology/how-companies-can-embrace-digital-disruption.

BUGHIN, J., LABERGE, L., MELLBYE, A. (2017). The case for digital reinvention. *McKinsey Quarterly*, 2, 1-15.

CAPGEMINI AND GT NEXUS. (2017). *The Current and Future State of Digital Supply Chain Transformation*. Retrieved from https://www.supplychain247.com/paper/the_current_and_future_state_of_digital_supply_chain_transformation

COX, J. F., BLACKSTONE, J. H., SPENCER, M. S. (1995). *APICS dictionary*. Falls Church, VA: American Production and Inventory Control Society.

DELOITTE'S DIGITAL SUPPLY NETWORKS. (2016). *The rise of the digital supply network*. Retrieved from https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-transformation-in-supply-chain.html.

GEZGIN, E., HUANG, X., SAMAL, P., SILVA, I. (2017). Digital transformation: Raising supply-chain performance to new levels. *McKinsey & Company*, 1-10.

GLAS, A. H., KLEEMANN, F. C. (2016). The impact of industry 4.0 on procurement and supply management: A conceptual and qualitative analysis. *International Journal of Business and Management Invention*, 5(6), 55-66.

HARTMANN, B., KING, W. P., NARAYANAN, S. (2015). Digital manufacturing: The revolution will be virtualized. *McKinsey Quarterly*, Aug.

HERMAN, M., PENTEK T., OTTO, B. (2015). *Design Principles for Industrie 4.0 Scenarios: A Literature Review*. Technische Universität Dortmund. Audi Stiftungslehrstuhl Supply Net Order Management. Retrieved from http://www.snom.mb.tu-dort- mund.de/cms/de/forschung/Arbeitsberichte/Design-Principles-for-Industrie-4_0-Scenarios.pdf

KORN FERRY INSTITUTE. (2017). *The Supply Chain Digital Disruption. - Korn Ferry*. Retrieved from https://www.kornferry.com/institute/download/download/id/18363/aid/1811

KORN FERRY INSTITUTE. (2018). *Struggles with the Digital Supply Chain*. Retrieved from https://www.kornferry.com/institute/digital-supply-chain.

KPMG. (2018). *Transforming for a digitally connected future*. Retrieved from https://home.kpmg/content/dam/kpmg/gr/pdf/2018/06/GM-TL-01066_2018%20GMO.pdf

LAMBERT, D. M. (2008). *Supply chain management: processes, partnerships, performance*. Supply Chain Management Inst.

MAIER, R., PASSIANTE, G., ZHANG, S. (2011). Creating value in networks. *International Journal of Innovation and Technology Management*, 8(03), 357-371.

McKINSEY SPECIAL COLLECTION DIGITAL STRATEGY, (2017), Retrieved from https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Strategy%20and%20Corporate%20Finance/Our%20Insights/Strategy%20and%20corporate%20finance%20special%20collection/Final%20PDFs/McKinsey-Special-Collections_DigitalStrategy.ashx

MENTZER, J. (2001). *Supply Chain management*. Sage Publications, Inc. 2001.

MORLEY M. (2017). *How Supply Chains are Embracing Digital Disruption*. Retrieved from https://blogs.opentext.com/supply-chains-embracing-digital-disruption/.

PONTIUS, N. (2017). *Transformation via Technology: The Key Drivers of Digital Supply Chain Disruption, Business.com / Technology*. Retrieved from https://www.business.com/articles/the-key-drivers-of-digital-supply-chain-disruption/.

SHERER, S. A. (2005). From supply-chain management to value network advocacy: Implications for e-supply chains. *Supply Chain Management*, 10(2), 77–83.

SMITH, P. (2018). *Supply Chain Digital Disruption – What Does It Mean For "Talent"?* Retrieved from http://spendmatters.com/uk/supply-chain-digital-disruption-mean-talent/.

WILLEMS, L., AGRELL, P. J., LEJEUNE, C. (2018). *On the Supply Chain in the Fourth Industrial Revolution*.

SECTION 4
–
SYSTEMS IN DIGITAL TRANSFORMATION

Maple Application in Economic Disciplines

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Abstract

Purpose of the article Efforts to use the Internet to make everyday activities as easy as possible is a current trend. The same applies to education, with teaching being gradually more and more supported by programs, applications and internet documents. The same goes for teaching of subjects in the field of mathematics and economics and their applications.

Methodology/methods One way to bring mathematics closer to students and encourage their creativity is the use of tools provided by ICT technologies. The use of ICT in teaching of mathematical and economic subjects has now come to the centre of attention of educators teaching these subjects. Engagement of computers and all ICT technologies in the teaching process may be of various quality and form. We can perceive the computer as a tool the educator uses to prepare their teaching aids, as well as the environment where the whole class works on solving a particular problem.

Scientific aim The aim is the use of Maple for solving differential equations, difference equations, functional differential equations and their economic applications.

Findings Incorporation of mathematical software (Maple, Matlab, Mathematica, etc.) can simplify work with functions created from real data for students. Students can get new motivation for work when they see that mathematics is not only a theoretical science but it can also be used as a tool in many fields. Studies show that students using Maple handle the curriculum content much better than those who learn in the traditional way. Improvement is obvious in all students regardless of initial knowledge level.

Conclusions By suitable and active incorporation of Maple into teaching a much larger amount of examples can be discussed since a number of routine calculations are eliminated. Maple allows students to model various economic situations and see immediately how these changes of external conditions affect the output. Many tasks stimulate critical mathematical thinking since it forces outcome estimates or checks and, last but not least, there are graphical outputs.

Keywords: Maple, mathematical software, ICT, teaching

JEL Classification: A230, A210, C630

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Introduction

Maple is a computer environment developed at the University of Waterloo in Canada to simplify and accelerate calculations in mathematics. Unlike traditional numerical calculation programs, it models mathematical operations with symbolic expressions. Maple enables symbolic and numerical calculations as well as function graphs, programming of custom functions or procedures, saving data in several formats and even export to programming languages. Maple implemented functions cover an extensive area of mathematics from basics of linear algebra, differential and integral count to differential equations, geometry and logic. The work is based on symbolic operations using the advantages of saving numbers in their exact format, therefore Maple gives results with much higher precision than in ordinary numerical calculations with movable decimal point. Maple is used not only for teaching but also for research and development. It is a very complex mathematical system providing various tools for real problem simulation.

There have been a lot of issues in teaching of mathematics at all school levels for many years. The field that was perceived as one of the absolute bases of education for many decades was gradually marginalised. At schools, mathematics is often regarded as unpopular, boring, hard, detached from reality and even useless.

Of course, these problems are reflected in university studies as well. The situation is slightly more favourable in fields immediately related to mathematics, usually attended by students who favour the subject. Problems are emerging in technical programmes where students more often than in the past have difficulties mastering mathematics, although many faculties lowered their requirements compared to the past. The situation is the least favourable in humanities, such as economics, sociology, law, etc. Here one often hears claims that mathematics (statistics, logic, …) is useless, not only from students, but sometimes also from the educators.

Thus the question stands how to prepare mathematics teaching, mostly in fields aimed "for mathematicians, how to bring the subject closer to the students, how to simplify its perception and, most of all, how to show that mathematics can play an important role even in their lives, as a discipline that presents various practically applicable tools and also as a field that cultivates systematic and logical thinking and develops the ability of objective perception of facts and, last but not least, contributes to creative everyday problem-solving. (Dostal, 2016)

One way to bring mathematics closer to students and encourage their creativity is the use of tools provided by ICT technologies. (Jehlička, 2018) Use of ICT in teaching of mathematics has become a subject of interest of educators who teach mathematics.

Engagement of computers and all ICT technologies in the teaching process may be of various quality and form. We can perceive the computer as a tool the educator uses to prepare their teaching aids, as well as the environment where the whole class works on solving a particular mathematical problem.

Incorporation of mathematical software (Maple, Matlab, Mathematica, etc.) can simplify work with functions created from real data for students. Students can get new motivation for work when they see that mathematics is not only a theoretical science but it can also be used as a tool in many fields. Studies show that students using Maple handle the curriculum content much better than those who learn in the traditional way. Improvement is obvious in all students regardless of initial knowledge level. (Ningsih 2018)

1 Basic mathematical tools used in teaching economics

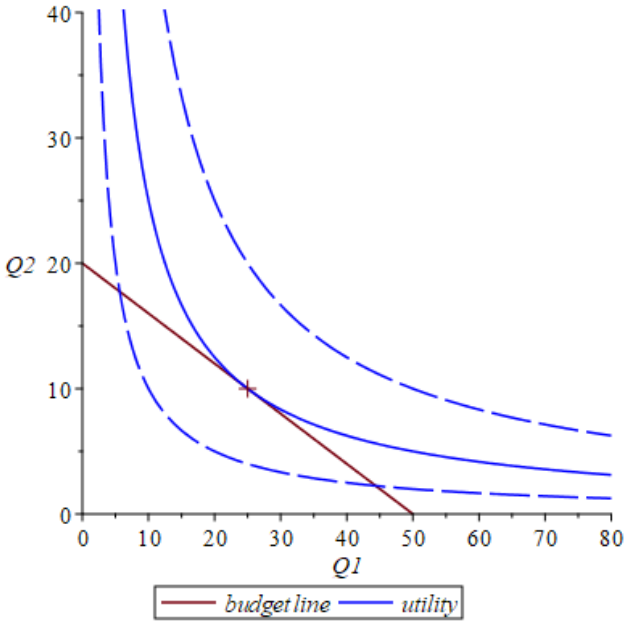
The aim of a basic economics course is not to prove using sophisticated mathematical methods how variable X affects the course of variable Y, but for the students become familiar with basic economic terms, be able to explain what its subject of inquiry is and why it is good to study economics in the first place. On the other hand, the use of the mathematical apparatus cannot be avoided in many cases. (Drábeková, 2015) It is completely necessary for basic courses of economics that the student has mastered solving systems of equations with two unknowns and most importantly learned to read graphs. These two skills constitute the absolute basics that are essential for students of basic courses of economics.

Basic courses are usually taught in the bachelor university programmes, advanced courses in master programmes. Students' ability to use mathematics as a tool for solving economic models is not sufficient, although the students consider the study of mathematics and statistics to be important. This is demonstrated by the fact that the students believe practical knowledge of mathematics and statistics to be significant. Problems occur mostly in the use of basic mathematical knowledge and its application to economic problems. Students often suffer from needless bias and fear to combine mathematical and economic knowledge and they tend to give up easily. At the level of basic microeconomics course, students are often challenged by reading a graph depicting any function.

As for advanced microeconomics courses, students should have mastered mathematical skills of grammar school graduates. These courses are taught mostly in follow-up master programmes. In optimization tasks in particular the use of derivations for finding extremes of utility, production, profit and cost functions is required, as well as for solving tasks measuring demand elasticity in order to deduce conclusions concerning investigated goods and services.

E.g. in optimization tasks, it is important that the students understand and apply Lagrange method of bound extremes. A model example can be the search for the maximum of the utility function bound by the condition of budgetary restriction. To get a better idea of the solution, it is advisable to depict the searched bound maximum graphically.

Example We will work with a particular utility function and the budgetary restriction. By applying Lagrange method of bound extremes, we will calculate the utility maximum. Maximum utility of 250 (full blue line) will be achieved at the point of the utility curve touching the budgetary restriction, i.e. at, see Figure 1. The blue dashed line shows higher and lower utility values. Higher utility (500) may not be achieved with the given budgetary restriction; to the contrary, lower utility (100) is not desirable with regard to the search for utility maximum.



Source: Elaborated in Maple by the author, 2019

Figure 1 Bound maximum

In advanced courses, students also face various types of differential equations, difference equations, functional differential equations and their applications. Mathematical models describing common everyday problems also include the application of this type of equations.

Mathematical models using delay functional differential equations are applied in areas we would not have expected few years ago. For instance, they are used in medicine in describing the process of substance effects on the body or spread of infectious diseases. In ecology, there are models describing populations of a single species as well as models of multi-species population dynamics. In physics the models describe the pantograph movement down the line or nuclear reactor dynamics, among other things. In microeconomics, the models describe price fluctuation and in macroeconomics they apply to the theory of economic cycles.

Maple offers three ways of solving differential equations:

1. Analytical solution with Maple searching for a solution in the form of a single-variable function,
2. Solution using infinite sequences with Maple looking for a solution in the form of an infinite power series,
3. Numerical and the closely related graphical solution.

All types of solutions in Maple are under one order, the dsolve procedure, which is one of the most useful and frequently used tools for solving differential equations. There is a large number of optional parameters in the dsolve procedure.

The analytical solution is the basic method of solving differential equations in Maple and the program has strong computing tools for this type of solution. Other solution methods are used when the analytical solution fails or when the result may not be expressed "in a nice form". The analytical solution by dsolve procedure is used most frequently of all the methods, therefore this type is preset and no other additional settings of optional parameters are necessary.

Some equations may not be solved analytically but we can solve those using power series.

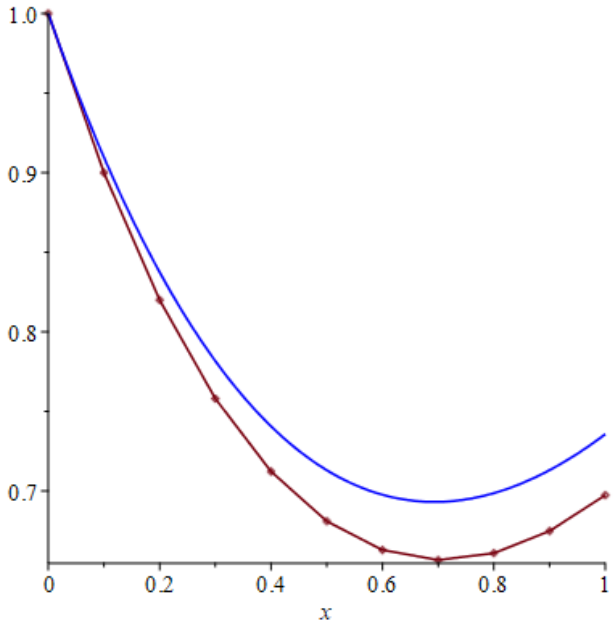
By numerical solution of ordinary differential equations we mean approximate solution of ordinary differential equations by methods of numerical mathematics. These methods are used in cases when finding an exact analytical solution is difficult in terms of computing or in cases when an analytical solution may not be found. The most common examples include non-linear differential equations, linear differential equations with non-constant coefficients or higher order linear differential equations with constant coefficients.

The graphical solution is closely related to the numerical solution or it is added as visualisation of function graphs obtained in the analytical solution. For these purposes, Maple provides a basic tool for graph depiction – plot procedure, or a special tool for graphical depiction of the numerical solution, the odeplot procedure from the plots library.

Example Euler's method is the basic method for the numerical solution of differential equations. By this method, we will find an approximate solution of the initial task

$$y' = x - y \qquad\qquad y(0) = 1$$

at interval [0;1]. We will use a ten-point power equidistant network. The graphical output is in Figure 2. The numerical solution graph is depicted in red, the analytical solution graph in blue.



Source: Elaborated in Maple by the author, 2019

Figure 2 Numerical and analytical solution graph

The primary aim of economic subject teaching at universities should be not only to provide knowledge but also to encourage practical application of the knowledge. On the other hand, practice should not underestimate scientific approach; it should require educated, thinking people able to use their knowledge pragmatically, and used to responsibility, independence and creativity as well as efficient work. Economic profile disciplines give students sufficient options for topic selection and compilation of their theses. The use of mathematical disciplines together with knowledge from practically oriented subjects in thesis drafting gives senior students wide range for

self-realization and together with a number of ICT tools, creates environment for deepening and strengthening the acquired knowledge.

2 Use of ICT

There are three broad categories of the applications of computers in the field of mathematics education: computer assisted instruction (CAI), student (educational) programming and general purpose educational tools such as spreadsheets, databases and computer algebra systems (CAS).

Presently it seems that university professors would benefit from combining information technologies with mathematics to show students the possibilities of using information technologies in mathematics. (Misut, 2015)

ICT technologies can be viewed as

a) Tool for teachers

The simplest way for computer technology to assist mathematics teaching is using the computer as an educator's tool for teaching preparation. At a time when university professors become the editors and often even publishers of their own textbooks, in paper or digital form, as is increasingly the case, the above skills may be regarded as the minimum standard.

b) Demonstration tool

The computer may serve as an illustrative demonstration tool in mathematics teaching, for the teacher to present new findings. A specially equipped classroom is required for computer aided teaching (computer + interactive board or projector), which is often not a standard at universities.

c) Tool for practice

Use of computers as practical tools used by students in mathematics is the most demanding form of teaching in terms of requirements. This is because such classes need to be taught in a fully equipped computer room where each student or a pair of students have their own computer. However, school computer room capacities are of-ten insufficient to meet the educators' requirements and specialized subjects are preferred.

Conclusions for Education

There is a major issue that during the study of mathematics, students often fail to see any practical application of what they are supposed to learn. Thus the bias against mathematics as such mentioned above may originate and economics is then often perceived just as another mathematics-oriented subject. However, economics is a science of human behaviour and mathematics serves for better understanding of the relations between real economic phenomena.

A possible solution may come in the form of certain humanization of mathematics and consistent explaining and reasoning of why the students are required to learn how to solve equations, examine function behaviour, to differentiate or integrate. Students should know that they are not learning something just for the sake of learning, something they will not apply in further study or practice. Of course, the same appeal goes to economics teachers who should consistently explain, demonstrate on examples and point out important connections any-time they try to extend the students' knowledge in the fascinating science of economics. Mathematics may never form a universal model of human behaviour but it definitely is a very suitable science that enriches economics and helps us to understand real economic phenomena, explain them and predict the effects of individual measures, the impact various changes might have on the economic reality, if external conditions shift. Maple allows students to model various economic situations and see immediately how these changes of external conditions affect the output. Not only numerically but also graphically.

References

DE WITTE, K. ET AL. (2015). The effectiveness of a computer-assisted math learning program. *Journal of Computer Assisted Learning*, 31(4), 314-329. Doi 10.1111/jcal.12090.

DOCKENDORFF, M., SOLAR, H. (2017). ICT integration in mathematics initial teacher training and its impact on visualization: the case of GeoGebra. *International Journal of Mathematical Education in Science and Technology*, 49(1), 66-84. Doi 10.1080/0020739X.2017.1341060.

DOSTAL, P. et al. (2016). Multicriteria Evaluation of Gifted Students. In *Innovation Management and Education Excellence Vision 2020: From Regional Development Sustainability to Global Economic Growth*. Milan, Italy: IBIMA, 262-268.

DRÁBEKOVÁ, J., ŠVECOVÁ, S. (2015). Some Notes on the Financial Literacy of the Slovak Students – Case Study. *Mathematics in Education, Research and Applications*, 01(02), 68-72. Doi 10.15414/meraa.2015.01.02.68-72

JEHLIČKA, V., REJSEK, O. (2018) A Multidisciplinary Approach to Teaching Mathematics and Information and Communication Technology. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(5), 1705-1718. Doi 10.29333/ejmste/85109.

MISUT, M., POKORNY, M. (2015) Does ICT Improve the Efficiency of Learning? *Procedia - Social and Behavioral Sciences*. 177, 306-311. Doi 10.1016/j.sbspro.2015.02.346.

NINGSIH, Y. L., PARADESA, R. (2018) Improving students' understanding of mathematical concept using maple. *Journal of Physics: Conference Series 948*. Doi 10.1088/1742-6596/948/1/012034.

Decision-Making Process Using Neuro-Fuzzy Model for Capital Market

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Abstract

Purpose of the article The paper discusses the proposal of a neuro-fuzzy model as support in decision-making on investments in exchange traded funds (ETF) focused on the real estate sector and listed on the American exchange. The created model is based on the neuro-fuzzy inference system (ANFIS).

Methodology/methods The methods of analysis, synthesis and mathematical neuro-fuzzy modelling were used to achieve the goal. Selected financial indicators represent the fuzzy system input. Based on the Gauss membership function, the neural network generates the fuzzy rules. The model output is a signal to buy or sell the ETF stock.

Scientific aim The paper aims to create a suitable model for decision-making on investments in analyzed investment instruments based on selected financial indicators.

Findings The proposed neuro-fuzzy decision-making model consists of 4 input variables, one rule block (with 81 fuzzy rules) and one output variable (to invest or not to invest). The input variables and the output variable have three attributes (L – large, M – medium, S – small). The created ANFIS model is a suitable tool for investment decisions on buying or selling ETF stock. The model significance lies mostly in the fact it provides the expert analyst or potential investor with enough space to express and incorporate their subjective evaluation in the model.

Conclusions The paper discussed the proposal of a neuro-fuzzy model as support in decision-making on ETF investment opportunities listed on the American market. For further research, the proposed model should be extended by other significant fundamental indicators, possibly incorporate technical and psychological indicators and monitor the strength of the revised model in other capital markets as well.

Keywords: fuzzy logic, artificial neural networks, stock market, stock trading, soft computing, ETF, ANFIS

JEL Classification: G11, G12, C45

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Introduction

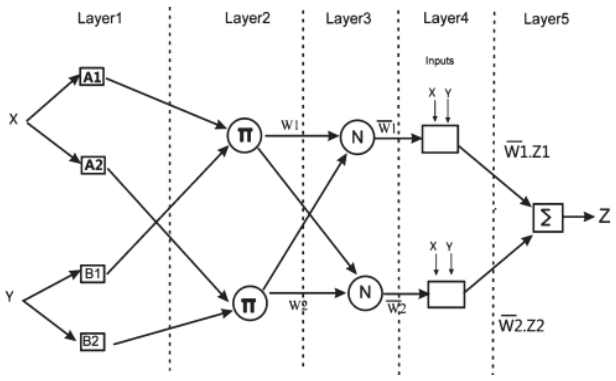
The financial industry has been increasingly dependent on advanced computer technologies, in particular due to the need to retain competitiveness in the global market. The issue of decision-making in capital market using data mining techniques is one of the most important areas in finance. This had drawn a lot of scientific attention and become the crucial research providing a more accurate forecast and decision-making process. As stated by Tung and Le (2017) and Zadeh (1978) fuzzy logic and artificial neural network are promising techniques with extensive forecast applications. More and more scientists and resarchers realize the fuzzy set theory introduced by Zadeh is a suitable instrument for mastering stock market uncertainties and ambiguities. Dostál and Kruljacová (2018) state that fuzzy logic and artificial neural network belong among soft computing methods. The guiding principle of fuzzy logic means to the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability and robustness. Artificial neural network has been widely accepted mostly for its ability to learn and reveal the relationships between non-linear variables. The artificial neural network primarily overcomes the statistical regression models and allows a deeper analysis of large data sets. The created model helps in decentralization of decision-making processes to be standardized, reproduced, and documented.

1 Theoretical Background

Since the data on investment instrument prices are affected by deterministic and random factors (Bao and Yang, 2008), a stock market forecast may be successful solely when instruments and techniques overcoming the price uncertainty and non-linearity problem are used, as mentioned by Chang et al. (2011). Wang and Wang (2015) state that fuzzy logic and neural networks are more and more frequently used in the financial markets and their prediction capability is widely acknowledged mostly thanks to their ability to detect non-linear behaviour. Jilani and Burney (2008) introduced a simple fuzzy time series forecasting method. Chang and Liu (2008) implemented a system based on Takagi-Sugeno-Kang (TSK) fuzzy rules for stock price prediction. Dostál and Kratochvíl (2011) applied fuzzy logic as decision-making support in stock markets. Similarly, Janková (2018) deals with fuzzy logic application in investment portfolio optimization as an effective tool in the upcoming digital age. Svalina et al. (2013) used the adaptive network system based on fuzzy inferences to predict the closeness of Crobex prices on the Zagreb Stock Exchange. The article by Gunasekaran and Ramaswami (2014) deals with stock portfolio optimization using the neuro-fuzzy inference system and the capital asset pricing model (CAPM). Atsalakis et al. (2016) used the neuro-fuzzy inference system for stock market predictions in turbulent times. The obtained results showed that the proposed model gives accurate stock price trend forecasts within the stock market crisis.

2 Neural Networks and Fuzzy Logic

The currently widespread data mining technique has provided a more accurate forecasting process and has attracted a lot of scientific attention. Tung and Le (2017) state that fuzzy logic and artificial neural network represent a method with a wide range of application in forecasting future stock price changes, exchange rates, commodities and other financial instruments. Fuzzy logic allows definitive conclusions to be drawn from un-clear, ambiguous or inaccurate information. Artificial neural network has been widely accepted mostly for its ability to learn and reveal the relationships between non-linear variables. The artificial neural network primarily overcomes the statistical regression models and allows a deeper analysis of large data sets.



Source: Gunasekaran and Ramaswami, 2014

Figure 1 ANFIS architecture

A hybrid neuro-fuzzy system was created by a combination of artificial neural networks and fuzzy logic. The system aims to use the advantages of both the neural networks and fuzzy logic. According to Karray and de Silva (2004), it takes the description of vagueness from fuzzy logic and the above mentioned ability to learn from the neural networks. Neuro-fuzzy systems use a neural network to avoid manual setting of various parameters and enable the system to learn them itself and possibly adapt. Negnevitsky (2002) emphasizes that ANFIS (Adaptive Neuro-Fuzzy Inference System) has become one of the widespread neuro-fuzzy systems.

Figure 1 depicts a multi-layer network, which includes an input layer, one or more hidden layers and one output layer, state Dostál (2011). Thanks to the multi-layer technology, neural networks are capable of better identification of non-linear relationships between input and output variable sets compared to other methods. As added by Fanta (1999), each neural network input corresponds to one variables. The neural network output is the task solution. Weights are key elements of the neural network, expressing the relative strength of input data or various connections transferring data between layers. Thus the weights express the relative significance of neural network input data. There is currently a number of various neural network architectures. Apart from the hidden structure model, there are systems with associative memory, double-layer structure, etc. In neural net-works, although they are mostly based on determination by examples and not predominantly on rules, there are algorithms that help determine the neural network, i.e. change the weights of the respective neurons in the calculation process.

3 Experimental Results and Analysis

The following part of the paper presents not only a selected data sample but also the required outputs. Then a model is created based on the neuro-fuzzy inference system (ANFIS). Based on the selected membership function, the neural network generates the fuzzy rules. The model output is a signal to buy or sell the ETF stock.

3.1 Data Sample

For the neuro-fuzzy model creation, 10 exchange-traded funds (ETF) in the real estate sector are selected. ETF are a suitable and cost effective instrument for investors who strive to acquire extensive market indexes, particular sectors or geographic regions, etc. The selected market is the Americal market that, according to ICI Factbook (2018), offers 1,832 ETF and 3.4 trillion dollars of managed assets and is the largest ETF organizer in the world. Table 1 shows selected ETF entering the model.

Table 1 Asset values of selected ETFs

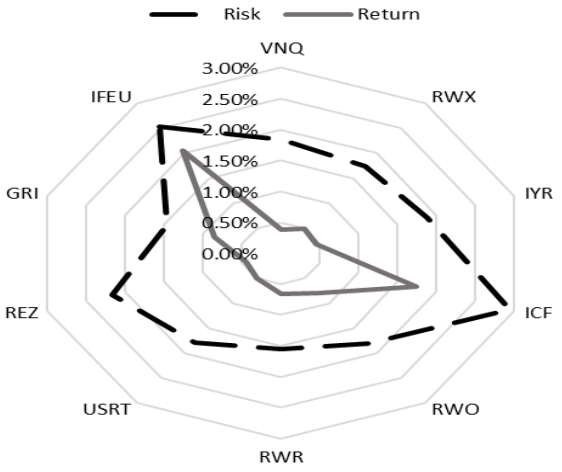
ETF	Ticker	AUM (bil. USD)
Vanguard Real Estate ETF	VNQ	32.3
SPDR DJ Wilshire International Real Estate ETF	RWX	2.3
iShares U.S. Real Estate ETF	IYR	4.6
iShares Cohen & Steers REIT ETF	ICF	2
SPDR DJ Wilshire Global Real Estate ETF	RWO	2.3
SPDR Dow Jones REIT ETF	RWR	2.8
iShares Core U.S. REIT ETF	USRT	1.1
iShares Residential Real Estate ETF	REZ	0.4
Cohen & Steers Global Realty Majors ETF	GRI	0.054
iShares Europe Developed Real Estate ETF	IFEU	0.031

Source: Finance Yahoo, 2018

3.2 Financial Indicators

Fang et al. (2006) state that return and risk are usually the two crucial factors considered by investors in in-vestment decision-making. Gupta et al. (2008) divides return to long term and short term and his model also includes dividends. In some cases, investors may consider other factors, such as liquidity. For example, liquidity was accounted for by Arenas et al. (2001) who tested the selected unit trusts using fuzzy logic. Other authors claim that ignoring transaction costs leads to ineffective portfolios, see Li et al. (2000) or Khayamim et al. (2018). For

this reason, the selected model input variables are: return, dividend, risk and total expanse ratio (TER). Figure 2 graphically depicts the values of the respective variables entering the model, except for very low TER values.



Source: Finance Yahoo, 2018

Figure 2 Return and Risk of ETFs

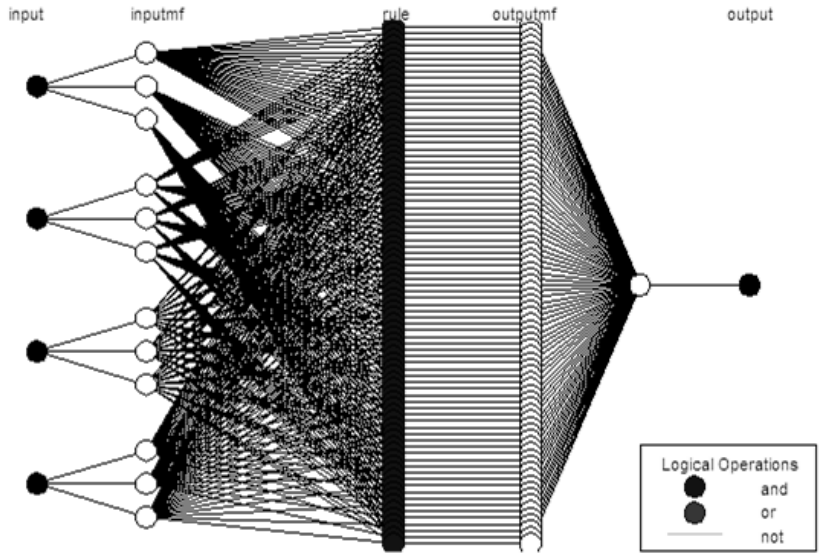
3.3 Experimental Results

Research results present an expert neuro-fuzzy model for decision-making on investments in ETF in the American stock market. First, it is necessary to determine the variables entering the model, their attributes and membership functions. The proposed neuro-fuzzy model consists of four input variables and one output variable. The inputs are represented by the following variables: return, dividend, risk and TER. There are 3 attributes of the input variables: High, Medium, Low. Gaussian membership function has been used. The output variable represents the BUY or SELL decision.

Based on the described procedure, the best fuzzy inference system (FIS) results are achieved with the following parameters:

- Generate FIS method: Grid partition.
- Train FIS optimum method: Hybrid learning.
- Gaussian membership function (gaussmf).

Gaussian membership function is selected in context to paper Talpur at al. (2017), when are compare the different membership functions. Their study shows that the Gaussian membership function is the most suitable among other selected membership function (triangular, trapezoidal, bell) when employed in ANFIS with grid partitioning method. Mayilvaganan and Naidu (2011) found that the best performance and results was obtained with using Gaussian membership function. The bell and trapezoidal membership function are poorer then Gaussian. Also, Esfahanipour and Aghamiri (2010) use Gaussian membership function in ANFIS to test the stock data.



Source: authors' research

Figure 3 ANFIS architecture

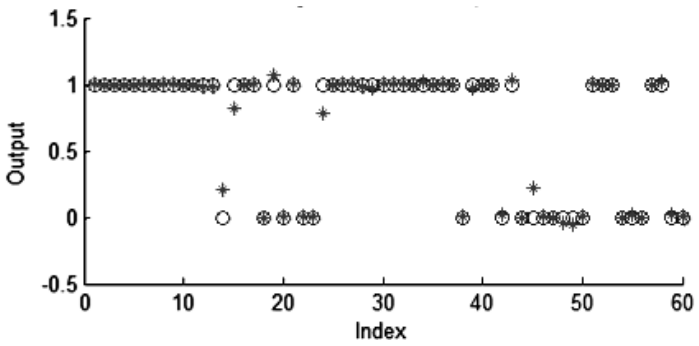
A rule block sample generated by artificial neural networks is shown in Table 2. ANFIS created a total of 81 IF-THEN rules. An example of the first rule meaning is as follows: If the return is high, risk low and overall fund costs low, the ETF is recommended for purchase. On the other hand, the last rule states: If both the return and risk are high as well as the total cost indicator, the ETF is recommended for sale.

Table 2 Examples of rule block

		IF		THEN
Return	Dividend	Risk	TER	Results
High	High	Low	Low	BUY
High	High	Low	Medium	BUY
High	High	Low	High	BUY
High	High	Medium	Low	BUY
High	High	Medium	Medium	BUY
High	High	Medium	High	BUY
High	High	High	Low	BUY
High	High	High	Medium	SELL
High	High	High	High	SELL

Source: authors' research

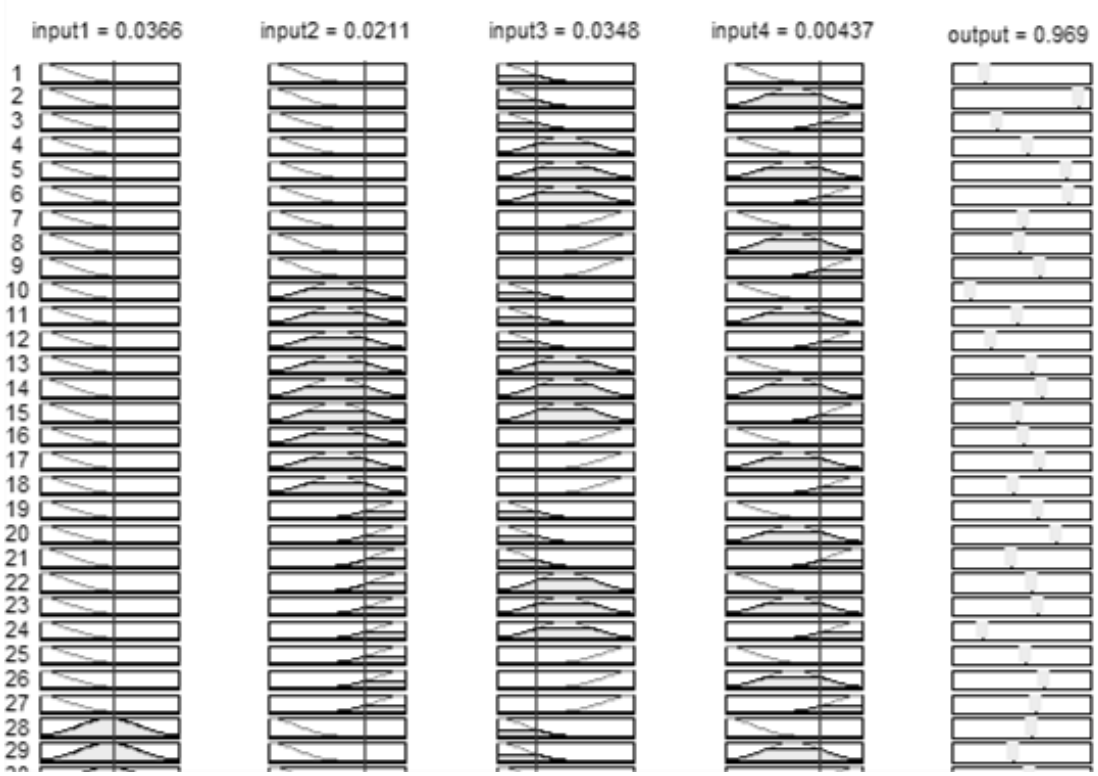
For this model, the number of training epochs is 30 and training error tolerance is set to zero. The training process stops whenever the maximum epoch number is reached or the training error goal is achieved. For splitting the data into training and testing purpose, according to literature (Sallah et al., 2018, Shrivastava and Sridharan, 2013) most researchers practiced the 70% training and 30% testing because the more data applied for the training, the more optimal and accurate results a system generates. Therefore, in this study the 70% of the dataset instances were selected for training set and the remaining 30% of the dataset instances were chosen for testing set. The error in the training process reached 0.055954. The figure 4 shows the testing of the data set which is slightly different from the one used to train the system. It is obvious that in the model learning most values were mapped to the adequate output value (1 – Buy ETF, 0 – Sell ETF).



Source: authors' research

Figure 4 Testing of the data set

Figure 5 depicts the decision-making process of ETF investments. The input variables of the created model in the case study are set as follows: risk = 3.66%, return = 2.11%, dividend = 3.48% and TER = 0.437%. Decision to invest or not to invest is 0.969, which is a value close to 1, thus based on the created neuro-fuzzy model, the recommendation is to invest in the ETF.



Source: authors' research

Figure 5 Part of table for decision making process

4 Discussion

The model includes key input variables that have been used in the long run as criteria for decision-making concerning investments not only in exchange-traded funds but also in other investment instruments. The neurofuzzy model is set for expert data, which may be further modified based on investor's requirements. If new relationships are identified, the model needs to be reviewed and verified again. As stated by Doskočil and Dostál (2017), only a verified model may be used for investment decision-making in practice. For this reason, the proposed neuro-fuzzy model may not be considered final and the only correct option.

However, Fullér (1995) notes some problems and limitations of fuzzy systems. A major issue for fuzzy control is stability, lack capabilities of learning and have no memory as stated previously, but neuro-fuzzy systems eliminate this drawback. Also, determining or tuning good membership functions are not always easy, even after extensive testing, it is difficult to say how many membership functions are really required. Verification and validation of fuzzy expert system generally requires testing with hardware in the loop. Salleh et al. (2017) mentioned that the computational cost of ANFIS is high due to complex structure and gradinent learning. This is significant bottleneck to applications with large inputs. Therefore, the more parameters in ANFIS architecture, the more is the training and computational cost. Interpretability is highly compromised, even through, the large number of rules contribute to improvement in model accuracy. More rules tend to produce better accuracy, on the other hand, it is difficult to interprete the model. Contrarily, reducing the rule-base may result in low accuracy.

Conclusion

The paper discussed the proposal of a neuro-fuzzy model as support in decision-making on ETF investment opportunities listed on the American market. For this purpose, financial indicators were used based on the analysis of previous published outputs concerning the issue of investments in financial markets. Based on the obtained results it can be stated that the proposed ANFIS model is a suitable tool for investment decision-making concerning the purchase and sale of ETF stock. The model significance lies mostly in the fact that although the neuro-fuzzy model is based on a number of quantitative data, the model provides an expert analyst with sufficient space to express and incorporate their subjective evaluation in the model. For further research, the pro-posed model should be extended by other significant fundamental indicators, possibly incorporate technical and psychological indicators and monitor the strength of the revised model in other capital markets as well.

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References

ARENAS, M., BILBAO, A., RODRIGUEZ, M. V. (2001). A fuzzy goal programming approach to portfolio selection. *European Journal of Operational Research*, 133, 287-297

ATSALAKIS, G. S., EFTYCHIOS, E. P., KIMON, P. V. (2016). Stock trend forecasting in turbulent market periods using neuro-fuzzy systems. *Operational Research*. 16(2), 245-269

BAO, D., YANG, Z. (2008). Intelligent stock trading system by turning point confirming and probabilistic reasoning. *Expert Systems with Applications*, 34(1), 620-627

CHANG, P. C., FAN, C. Y., LIN, J. L. (2011). Trend discovery in financial time series data using a case based fuzzy decision tree. *Expert Systems with Applications*, 38, 6070-6080

CHANG, P. C., LIU, C. H. (2008). A TSK type fuzzy rule based system for stock price prediction. *Expert syst appl*., 34, 135–144

DOSKOČIL, R., DOSTÁL, P. (2017). Project success evaluation model based on FIS. In *Perspectives of business and entrepreneurship development in digital age: economics, management, finance and system engineering from the academic and, practitioners views*, 149-155

DOSTÁL, P., KRULJACOVÁ, A. (2018). Evaluation of University Quality via Fuzzy Logic. In *Innovation Management and Education Excellence through Vision 2020*, 1368-1375

DOSTÁL, P. (2011). *Advanced Decision Making in Business and Public Services*. Brno: Academic Publishing House CERM

DOSTÁL, P., KRATOCHVÍL, O. (2011). Stock Market Fuzzy Decision Making. *Technical Computing*, 35, 4

ESFAHANIPOUR, A., AGHAMIRI, W. (2010). Adapted Neuro-Fuzzy Inference System on indirect approach TSK fuzzy rule base for stock market analysis. *Expert Systems with Applications*, 37(7), 4742-4748

FANG, Y., LAI, K. K., WANG, S. (2006). Portfolio rebalancing model with transaction costs based on fuzzy decision theory. *European Journal of Operational Research*, 175(2), 879-893

FANTA, J. (1999). *Technologie umělé inteligence na kapitálových trzích*. Praha: Karolinum

FINANCE YAHOO. (2018). Available at: https://www.financeyahoo.com/. [Accessed 15 January 19]

FULLÉR, R. (1995). *Neural fuzzy systems*. Åbo akademis tryckeri

GUNASEKARAN, M., RAMASWAMI, S. (2014). A hybrid intelligent system of ANFIS and CAPM for stock portfolio optimization. *Journal of Intelligent and Fuzzy Systems*, 26(1), 277-286

GUPTA, P., KUMAR, M. M., SAXENA, A. (2008). Asset portfolio optimization using fuzzy mathematical programming. *Information Sciences*, 178(6), 1734-1755

ICI Factbook. (2018). Investment Company Institute Factbook. Invesment Company Institute

JANKOVÁ, Z. (2018). Využití fuzzy logiky při optimalizaci investičního portfolia. In *Workshop specifického výzkumu 2018*. Brno: Vysoké učení technické v Brně, Fakulta podnikatelská, 101-109

JILANI, T., BURNEY, S. (2008). A refined fuzzy time series model for stock market forecasting. *Physica A*, 387, 2857–2862

KARRAY, F. O., DE SILVA, C. (2004). *Soft Computing and Intelligent Systems Design: Theory, Tools and Applications*. Pearson

KHAYAMIM, A., MIRZAZADEH, A., NADERI, B. (2018). Portfolio rebalancing with respect to market psychology in a fuzzy environment: A case study in Tehran Stock Exchange. *Applied Soft Computing*, 64, 244-259

LI, Z. F., WANG, S. Y., DENG, X. T. (2000). A linear programming algorithm for optimal portfolio selection with transaction costs. *International Journal of Systems Science*, 31(1), 107-117

MAYILVAGANAN, M. K., NAIDU, K. B. (2011). Comparison of membership functions in adaptive-network-based fuzzy inference system (ANFIS) for the prediction of groundwater level of a watershed. *Journal of Computer Applications Research and Development*, 1(1), 35-42

NEGNEVITSKY, M. (2002). *Artificial Intelligence: A Guide to Intelligent Systems*. Addison- Wesley

SALLEH, M. N. M., TALPUR, N., TALPUR, K. H. (2018). A Modified Neuro-Fuzzy System Using Metaheuristic Approaches for Data Classification. Artificial Intelligence - Emerging Trends and Applications. *InTech*.

SALLEH, M. N. M., TALPUR, N., HUSSAIN, K. (2017). Adaptive Neuro-Fuzzy Inference System: Overview, Strengths, Limitations, and Solutions. Springer International Publishing, 527-535

SHRIVASTAVA, H, SRIDHARAN S. (2013). Conception of data preprocessing and partitioning procedure for machine learning algorithm. *International Journal of Recent Advances in Engineering & Technology*, 1(3)

SVALINA, I., GALZINA, V., LUJIĆ, R., SIMUNOVIĆ, G. (2013). An adaptive network-based fuzzy inference system (ANFIS) for the forecasting: the case of close price indices. *Expert Syst. Appl.*, 40, 6055-6063.

TALPUR, N, SALLEH, M. N. M., HUSSAIN, K. (2017). An investigation of membership functions on performance of ANFIS for solving classification problems. *IOP Conference Series: Materials Science and Engineering*, 226.

TUNG, K., THANH, LE, M. H. (2017). An Application of Artificial Neural Networks and Fuzzy Logic on the Stock Price Prediction Problem. *JOIV: International Journal on Informatics Visualization*, 1(2), 40-49.

WANG, J., WANG, J. (2015). Forecasting stock market indexes using principle component analysis and stochastic time effective neural networks. *Neurocomputing*, 156, 68-78.

ZADEH, L. A. (1978). Fuzzy sets as a basis for a theory of possibility. *Fuzzy Sets and Systems*, 1, 3–28.

Taylor Approximation of Multilateral Resistance Term with Unilateral Variable in STATA

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Abstract

Purpose of the article The article presents the estimation of a gravity model on a bilateral data set of 132 countries. A multilateral resistance term (MRT) is included in the gravity equation. The paper demonstrates a solution using Taylor approximation of MRT with variables that are both bilateral and unilateral.

Methodology/methods The estimation of parameters in panel data is described in this paper. A Poisson pseudo maximum likelihood estimator (PPML) and Taylor approximation of MRT were used to estimate unknown parameters. All calculations were obtained using STATA software. Variable distance, regional trade agreements, common language and contiguity were used as gravity variables. Institutional variables were also included in the gravity model.

Scientific aim It has already become a standard routine to include typical gravity variables (distance or dummy variables of trade) into a multilateral resistance term. On the other hand, trade between two countries can also be influenced by institutional variables or by variables describing infrastructure. The aim of the paper is to estimate the gravity equation for panel data containing 132 countries over the period 2006–2015 and to include a unilateral variable into the multilateral resistance term.

Findings Although it is not possible to include a unilateral institutional variable directly into a multilateral resistance term and estimate its parameters due to problems with collinearity, this problem can be solved by using institutional distance. This variable is defined as the absolute value of the difference between the two institutional variables for the reporter and partner country. This simple procedure can be programmed, for example, in STATA.

Conclusions The common gravity variables affect the volume of trade between two countries as well as the selected institutional variables and GDP of the reporter and partner country.

Keywords: multilateral resistance term, Taylor expansion, gravity model, PPML

JEL Classification: C51, F13, F14

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Introduction

We suppose that trade flows between two countries are influenced by their sizes and by the distance between them. This theory is closely connected with Newton's gravity equation (Tinbergen, 1962). The gravity equation is used in its basic form defining mutual trade to be proportional to the GDP of both countries and influenced by the square of their mutual distance.

Gravity models of international trade have become widely used over the last fifty years (Anderson, 1979; Baldwin and Tagliony, 2007). On the other hand, several disputes have arisen in connection with this model (Trefler, 1995; McCallum, 1995; Deardoff, 1998; Helpman et al., 2008). The gravity equation is used to explain econometrically the effects of standard gravity variables (distance, national borders, currency unions, language and other "trade variables") on bilateral trade flows. In addition to these bilateral variables, there is a wide range of unilateral (country-specific) variables – institutional variables describing infrastructure – that can also affect the volume of trade (Alvárez et al., 2018; Yu et al., 2015; Gil-Pareja et al., 2017).

The debate has also focused on the performance of various estimation techniques. The traditional form of gravity model is log-linear. Such a model can be estimated using simple least squares (OLS) to obtain estimates of parameters by fixed effects. Although this method is very simple to implement, it has one serious drawback. We must drop any variables from the model that only vary by reporter (or partner) country and are constant in one dimension. Moreover, such specification is problematic in the case of zero observations (due to logarithms) and the OLS estimate may be inconsistent (Silva and Tenreyro, 2006 and Silva and Tenreyro, 2011). Nowadays, recent development is turning attention to the usage of the Poisson pseudo-maximum likelihood. This estimator allows the inclusion of zero values of trade flows into the estimation. An alternative to the fixed effect may be the approach of Baier and Bergstrand (2009) based on a first-order Taylor series approximation of two nonlinear multilateral resistance terms (MRT).

This paper describes an estimation of parameters in a gravity equation and we demonstrate a modeling of MRT by Taylor approximation in Stata. We adopt Taylor approximation strategies and discuss the possibility of inclusion of country-specific unilateral variables into the MRT. The model is estimated on a bilateral panel dataset of 132 countries between 2006 and 2015. Since we are working with bilateral data over a 10-year period, it is absolutely necessary to use advanced software, a suitable data structure and pre-prepared codes. In Section 2 we describe the gravity equation and discuss the methodology, in Section 3 we present Stata commands, and Section 4 concludes the paper.

1 Gravity equation

Anderson (1979) was the first to provide a microfoundation of the gravity equation. Bergstrand (1985) continued and supported his theory. We suppose that trade flows depend on reporter (or domestic) and partner (or foreign) GDP and on the distance between these two economies representing trade costs.

A classical form of gravity equation widely presented in the literature (Anderson and Wincoop, 2003; Head and Mayer, 2014; Shepherd, 2013) is the following:

$$X_{ijt} = \frac{Y_{it} \times Y_{jt}}{Y_t} \left(\frac{t_{ijt}}{p_{it} \times p_{jt}} \right)^{(1-\sigma)} \tag{1}$$

where X_{ijt} in equation (1) represents mutual trade flows from country i (reporter) to country j (partner). The total number of countries is N. Y_t denotes world GDP computed as the sum of GDP for all countries in the sample, Y_{it} and Y_{jt} are the GDP of reporter and partner countries i and j respectively, t_{ij} is the cost in partner country j of importing a type of goods from reporter country i, σ>1 is the elasticity of substitution and pit and p_{jt} represent exporter and importer ease of market access or country i's outward and country j's inward multilateral resistance terms.

The standard linear gravity equation presented by Anderson and van Wincoop (2003) is as follows:

$$logX_{ijt} = \beta_0 + logY_{it} + logY_{jt} + (1-\sigma) \times \left(logt_{ijt} - p_{it} - p_{jt} \right) \tag{2}$$

or alternatively

$$logx_{ijt} = \beta_0 + (1-\sigma) \times \left(logt_{ijt} - p_{it} - p_{jt} \right) \tag{3}$$

where β_0=-lnY_t, the variables pit and pjt are the multilateral resistance terms and are defined as a function of each country's full set of bilateral trade resistance terms, $logx_{ijt}=logX_{ijt}-logY_{it}-logY_{jt}$. Multilateral terms p_{ij} and p_{jt} are not observable and should be estimated. Baier and Bergstrand (2009) proposed the estimation of MRT from equations (2) and (3) by first-order log-linear Taylor-series expansion:

$$p_{it} = \sum_{j=1}^{N} \theta_{jt} lnt_{ijt} - \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \theta_{it}\theta_{ijt} lnt_{ijt} \tag{4}$$

$$p_{jt} = \sum_{i=1}^{N} \theta_{it} lnt_{ijt} - \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \theta_{it}\theta_{ijt} lnt_{ijt}$$

where the second term in both equations is a constant across country pairs and $\theta_{jt} = \frac{Y_{jt}}{Y_t}$, $\theta_{it} = \frac{Y_{it}}{Y_t}$ are defined as GDP weights. To deal with the problem of endogeneity, Baier and Bergstrand (2009) and Egger and Nelson (2011) recommend using simple averages $\theta_{it} = \theta_{jt} = \frac{1}{N}$ instead of GDP weights. Equation (3) yields the model:

$$logx_{ijt} = \beta_0 + (1-\sigma) \times \left(logt_{ijt} - \sum_{j=1}^{N} \theta_{jt} lnt_{ijt} = \sum_{i=1}^{N} \theta_{it} lnt_{ijt} + \sum_{i=1}^{N}\sum_{j=1}^{N} \theta_{it}\theta_{ijt} lnt_{ijt} \right) \tag{5}$$

As mentioned above, the log-linear form of the model can lead to inefficient estimations since the properties of the error term are changed (Silva and Tenreyro, 2006). The variance of the estimated parameters obtained by standard OLS can be biased and there can be problems with the t-values of estimated parameters. Hence, there is a necessity for other estimation techniques for estimating the gravity equations. There are many possibilities for obtaining estimates: Nonlinear Least Squares (NLS), Feasible Generalized Least Squares (FGLS), Gammpa Maximum Likelihood (GPML) or Poisson Pseudo-maximum Likelihood (PPML). The Poisson pseudo-maximum likelihood preserves total trade flows, i.e. the sums of the actual and predicted trade flows are identical (Arvis and Shepherd, 2012). PPML is an estimation method for gravity models. This estimator is a generalized linear model and is estimated via GLM using the quasipoisson distribution and a log-link. The PPML estimator has a number of additional desirable properties for applied policy researchers using gravity models. Its main advantage is that the Poisson estimator naturally includes observations for which the observed trade value is zero, interpretation of the coefficients is straightforward and follows the same pattern as under OLS.

2 Estimation in Stata

In this section we demonstrate the estimation of MRT in Stata. For these empirical examples we use a dataset on bilateral trade panel data for the 132 countries over the period 2000–2015. We use the COMTRADE data on export and import flows representing our dependent variable, WDI WB data on the GDP of the reporter and partner countries. For estimation purposes, we specify the last part of the model (5) as the trade cost function t_{ij}. This function is defined as follows:

$$\begin{aligned} logt_{ijt} = \alpha_1 logdist_{ij} + \alpha_2 contig_{ijt} + \alpha_3 comlang_{ijt} + \alpha_4 colony_{ijt} + \alpha_5 RTA_{ijt} \\ + \alpha_6 Institutional_variable_{ijt} \end{aligned} \tag{6}$$

Dist is the geographical distance between the reporter and partner country, *contig* is a dummy (=1 for countries that share a land border), *comlang* is a dummy (=1 for countries that have a common official language), *colony* is a dummy (=1 for countries which were in a colonial relationship in the past), and *RTA* is a dummy (=1 in the case that regional trade agreements exist between countries). Moreover, we also decided to include institutional variables: Trade Freedom (*TF*), Investment Freedom (*IF*) and Business Freedom (*BF*) to demonstrate that it is possible to have a country-specific variable in a multilateral resistance term. To avoid the problem of multi-collinearity, we have defined this variable as the absolute value of the difference between two unilateral variables for reporter and partner country in each year:

$$\begin{aligned} TF_differ_{ijt} &= |TF_{it} - TF_{jt}| \\ IF_differ_{ijt} &= |IF_{it} - IF_{jt}| \end{aligned} \tag{6}$$

$$BF_differ_{ijt} = |BF_{it} - BF_{jt}|$$

The source of all these variables is Heritage Foundations. Hence, our database contains 276,672 rows for 11 different variables. For this reason, it is very important to work with the data file carefully, save the data in the appropriate format, and choose the appropriate software to process it. There are many options for the choice of which statistical software to use for data processing. The R program works very well with large data (it makes it possible to process terabyte data, for example; pbdR represents a package for statistical computing with data using high-performance statistical computation. However, our data is not of such size, and for the purposes of economic interpretation of the results, the STATA program allows you to read data directly on-line. In our case, we use preprepared codes that can be changed as needed.

As mentioned above, OLS is an estimation strategy for a variety of gravity models. On the other hand, OSL is subject to criticism from the econometric point of view. Therefore, we present the alternative estimator PPML where we assume that a country's share in world GDP at time t is equal ($\theta_{it} = \theta_{jt} = \frac{1}{N}$) to avoid problems with endogeneity (Baier and Bergstrand, 2009).

Table 1 Simplified output from STATA: PPML estimates of a simple gravity model according to the Baier and Bergstrand (2009) methodology.

```
g theta = 1/132
g theta2 = 1/(132*132)

local bilateral_vars TF_differ IF_differ BF_differ lndist contig comlang colony
rta
foreach var of local bilateral_vars{
       g `var'_r=theta *`var'
       g `var'_p=theta *`var'
       g `var'_rp=theta2 *`var'

       egen MR`var'1=total(`var'_r), by(partnercode years)
       egen MR`var'2=total(`var'_p), by(reportercode years)
       egen MR`var'3=total(`var'_rp), by(years)

       generate MR_`var'N=`var' - MR`var'1 - MR`var'2 + MR`var'3

ppml ln_X  lnGDP_X lnGDP_M  MR_lndist   MR_contig MR_comlang MR_colony MR_rta
MR_BF_differ  years*, cluster (distw)

ppml ln_X  lnGDP_X lnGDP_M  MR_lndist   MR_contig MR_comlang MR_colony MR_rta
MR_TF_differ  years*, cluster (distw)

ppml ln_X  lnGDP_X lnGDP_M  MR_lndist   MR_contig MR_comlang MR_colony MR_rta
MR_IF_differ  years*, cluster (distw)
}
```

Source: own calculation

We have run several experimental estimates which are presented in Table 2. We estimated three specifications of a model with a multilateral resistance term where we approximated parameter θ by *1/N*. We also included three different institutional variables. The economic theory underlying the gravity model suggests that the estimated parameters of the GDP-level variable should be approximate unity with bilateral dependent variable trade. Although we did not apply any constraints to GDP coefficients to be equal to unity, the values of the estimated parameters are very close to 1. Both reporterter and partner GDP are significant across all three models. Geographical distance has the expected sign and magnitude. This variable is negative and significant and has a negative impact on trade for all three models.

Some of the bilateral gravity variables selected as trade variables and included in the multilateral resistance term are significant. Since variable *MR_contig* is significant, we can conclude that higher trade is observable between countries that share a land border or a border across a small body of water. A similar relationship exists between volume of trade and variable *MR_RTA*. Regional trade agreements such as EU, NAFTA etc. also have a positive impact on exports from reporter to partner country. On the other hand, a common language or colonial history between two countries does not have an influence on trade flows.

We also included three institutional variables. Of the many possibilities, we chose trade, investment and business freedom. All these three variables were measured as an institutional distance and its estimated parameters are significant. Hence, institutions also have some impact on trade volumes.

Table 2 Estimation Results

Variable name (dep.var: trade flowsijt)	(Model I)	(Model II)	(Model III)
Log_GDP_partner	0.77527***	0.75934***	0.76854***
	(0.8676)	(0.0413)	(0.0432)
Log_GDP_reporter	0.86768***	0.85781***	0.85467***
	(0.0435)	(0.0391)	(0.0340)
Log_distance	-0.43197***	-0.41017***	-0.40629***
	(0.0814)	(0.0726)	(0.0785)
MR_contig	1.30262***	1.30010***	1.3138***
	(0.1885)	(0.18053)	(0.1907)
MR_comlang	0.20010	0.19653	0.21358
	(0.1506)	(0.1476)	(0.1504)
MR_colony	-0.12279	-0.04370	-0.08235
	(0.1670)	(0.1606)	(0.1630)
MR_RTA	0.45782***	0.48928***	0.45400***
	(0.1371)	(0.1201)	(0.1262)
MR_TF_differ	0.01980**		
	(0.0091)		
MR_IF_differ		0.00195***	
		(0.0030)	
MR_BF_differ			0.00950**
			(0.0043)
No.obs	237866	237866	237866
R-squared	0.7664	0.7909	0.7713

PPML regressions with time fixed effects and multilateral resistance terms. Numbers in parentheses are robust standard errors of the estimates. Asterisks denote a level of significance: * of 10 %, ** of 5 %, *** of 1 %.

Source: own research

3 Conclusion

In this paper we have analyzed a panel of bilateral trade flows to show how to estimate the coefficients of a multilateral resistance term in STATA. If we have a well-organized dataset, then it is not too complicated to estimate the gravitational model with a multilateral resistance term in STATA. For this purpose, we can use a predefined function to calculate the estimates by command ppml. Moreover, we have demonstrated that it is possible to include institutional variables among other gravity factors. We have found that exports depend on geographical distance, with a negative relationship, as well as on the GDPs of the reporter and partner countries. Exports are also influenced by institutional variables. Finally, it should be noted that it would be possible to include a larger number of institutional variables in the model. Similarly, it would also be possible to examine the infrastructure of a selected country in addition to its institutions. This topic may be the subject of further research.

References

ÁLVAREZ, I. C., BARBERO, J., RODRÍGUEZ-POSE, A., ZOFÍO, J. L. (2018). Does Institutional Quality Matter for Trade? Institutional Conditions in a Sectoral Trade Framework. *World Development*, 103, 72-87.

ANDERSON, J. E. (1979). Theoretical Foundation for the Gravity Equation. *American Economic Review*, 69(1), 106-116.

ANDERSON, J., VAN WINCOOP, E. (2003). Gravity with Gravitas: A Solution to the Border Puzzle. *The American Economic Review*, 93(1), 170-192.

ARVIS, J. F., SHEPHERD, B. (2012). The Poisson quasi-maximum likelihood estimator: a solution to the adding up problem in gravity models. *Applied Economics Letters*, 20(6), 1-11.

BAIER, S. L., BERGSTRAND, J. H. (2009). Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation. *Journal of International Ec*onomics, 77(1), 77-85. Doi 10.1016/j.jinteco.2008.10.

BALDWIN, R., TAGLIONI, D. (2006). Gravity for dummies and dummies for gravity equations. *NBER Working Paper*, No. 12516. Doi 10.3386/w12516.

BERGRSTRAND, J. H. (1985). The gravity equation in international trade: some microeconomic foundations and empirical evidence. *Review of Economics and Statistics*, 67(3), 474-481.

DEARDORFF, A. (1998). Determinants of bilateral trade: Does gravity work in a neoclassical world? In: FRANKEL J. A. (Ed.) *The Regionalization of the World Economy*, 1st ed. University of Chicago Press, Chicago, pp 7-32.

Egger, P. & Nelson, D. (2011). How bad is antidumping? Evidence from panel data. *The Review of Economics and Statistics*, 93(4), 1374-1390.

GIL-PAREJA, S., LLORCA-RIVERO, R., MARTÍNEZ-SERRANO, J. A. (2017). Corruption and international trade: A comprehensive analysis with gravity. *Working paper WPAE-2017-05*, University of Valencia.

HEAD, K., MAYER, T. (2014). Gravity Equations: Workhorse, Toolkit and Cookbook. In GOPINATH, G:, HELPMAN, E., ROGOFF, K. (Ed.) *Handbook of International Economics*. 131-195, Vol. 4.

HELPMAN, E., MELITZ, M., RUBINSTEIN, Y. (2008). Estimating trade flows: Trading partners and trading volumes. *QJ Econ*, 123, 441-487.

McCALLUM, J. (1995). National Borders Matter: Canada-U.S. Regional Trade Patterns. *The American Economic Review*, 85(3), 615-623.

SHEPHERD, B. (2013). *The gravity model of international trade: a user guide*. ARTNeT Gravity Modeling Initiative, United Nations. Retrieved from http://www.unescap. Org/sites/default/files/tipub2645.pdf.

SANTOS SILVA, J. M. C., TENREYRO, S. (2006). The log of gravity. *The Review of Economics and Statistics*, 88(4), 641-658.

SANTOS SILVA, J. M. C., TENREYRO, S. (2011). Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator. *Economics Letters*, 112(2), 220-222.

TINBERGEN, J. (1962). *Shaping the World Economy; Suggestions for an International Economic Policy*. New York: Twentieth Century Fund.

TREFLER, D. (1995). The case of the missing trade and other mysteries. *American Economic Review*, 85(5), 1029-1046.

YU, S., BEUGELSDIJK, S., DE HAAN, J. (2015). Trade, Trust and the Rule of Law. *European Journal of Political Economy*, 37, 102-115.

Mathematical and numerical study of a SIR epidemic model on network with standard incidents

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Abstract

Purpose of the article With the expansion and use of computers and the Internet in everyday life, there has also been an increase in their abuse. The system connection by the Internet increases vulnerability of the connected networks and computers as well as the danger of information abuse or loss, e.g. through computer viruses. As the operating systems are becoming more complicated and complex, it is a bigger challenge for virus authors to attack these systems. In this paper, we formulate a model of computer virus spreading, inspired by the SIR dynamic epidemic model.

Methodology/methods The theory is briefly explained in the opening part and serves as a basis for formulation of the relationships between the quantities investigated in the paper. The results are demonstrated on particular examples and the behaviour of the model is presented using computer simulation. The solution incorporates the theory of mathematical analysis and ordinary differential equations.

Scientific aim The authors' aim is to analyse the computer virus spread model as a system of non-linear differential equations and verify its solvability.

Findings The proposed model is based on a system of non-linear differential equations and allows a qualitative view of its behaviour, simulated by Maple and graphically presented in the application part, for various input values.

Conclusions These days, all users should be familiar with computer security and data protection. The users should know how to protect and secure their data. This requires the knowledge of behaviour of various types of harmful software. Thus the model we have designed may significantly contribute to formulation of a defence strategy against computer virus spreading.

Keywords: computer virus, SIR, epidemic model, network, simulation

JEL Classification: C02, C60, D85

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Introduction

In today's society, computers have become an integral part of life. As computers and the Internet are used more extensively in everyday life, there has also been an increase in their abues, in particular in the form of a risk of device infection by a harmful code. We use the computer today in nearly all activities – in communication, contract conclusion, etc. Therefore we must be aware of the importance of computer safety and data protection. Users these days are threatened by ever new infiltrations and the attackers' resourcefulness is infinite. For this reason, computer security should not be the sole interest of companies but also of common users who should protect their data susceptible to abuse.

The computer viruses have reached the current form by a long process of evolution. New trends have been added in the course of the development, adjusting to new technologies and types of operating systems. In this paper, we formulate a model of computer virus spreading, inspired by the SIR dynamic epidemic model. The model is described by a system of non-linear differential equations and allows a qualitative view of its behaviour, simulated by Maple and graphically presented in the application part, for various input values. The au-thors' aim is to analyse the computer virus spread model as a system of non-linear differential equations and verify its solvability.

1 Literature Review

Computer viruses are harmful codes or programs that may replicate and spread through cable or wireless connection. With an increasing number of internet applications, computer viruses are a big threat to our work and everyday life. With the introduction of the Internet of Things and 5G, the threat is becoming more and more serious. As a result, it is important to understand how computer viruses spread on the Internet and to propose effective measures to solve this problem. To achieve this goal, it is advisable to get inspiration from biological virus spread in the population, considering their similarity to computer virus spreading (Kephart et al, 1993).

Mahtematical biological epidemic models have been studied for centuries and already in the mid-18th century, David Bernoulli developed one of the first known models inspired by the smallpox virus (Bernoulli, 1760). Infectiousness is one of the main common features shared by both computer and biological viruses (Cohen et al, 1987).

Based on these facts, some traditional epidemic models have been applied, such as SIRS, SEIR, SEIRS, SEIQV a SEIQRS. They display the computer virus spreading as follows: (1) Susceptible persons correspond to non-infected computers, (2) latent patients correspond to infected computers in which all the viruses are latent, and (3) infecting patients correspond to infected computers containing at least one virus. In biological environment, it is well known that an infected latent person cannot infect other individuals. However, in the computer environment, a latent infected computer can infect other computers, e.g. through file copies or downloads. Un-fortunately, all previous computer virus models have not taken this passive infectiousness into account. A reasonable virus computer model should assume that both defective and latent computers are infectious (Yang et al, 2013).

The development and analysis of mathematical models of these systems can allow understanding of virus spreading behaviour, which can bring long-term benefits for the society as a whole. Several traditional epidemic models used for describing the spreading of harmful files – viruses are described below:

- SIR (susceptible-infected-removed) is strictly based on the biological SIR model. This method is restricted to cases when all community members demonstrate the same level of susceptibility to the dis-ease at the beginning (Kermack et al, 1927).
- A fundamental model on which many other models are based is SIS (susceptible-infected-susceptible). In the basic SIS model, in every step, every single node or agent is either infected or susceptible to infection. Any other agent can be infected by the adjacent agents with a given infection rate β, where the network graph structure determines the connection between the individual agents, and therefore plays a direct role in facilitating or preventing infection spread. An infected agent can be cured with a certain rate of treatment δ, by which it returns to the initial susceptibility state. The first SIS model was developed in the mid-20th century by Kermack and McKendrick (Kermack et al, 1932).
- The SEI model (susceptible, exposed, infected) is an adjusted version of the SEI epidemiology model. This model assumes virus spread through P2P (peer to peer) network and classifies each role as one of three categories based on the number of shared infected files (Thommes et al, 2005).

- SEIR (susceptible, exposed, infected, recovered) is a disease spread model with an exponential demographic structure with a natural mortality constant and excessive mortality rate in infectious individuals (Yan et al, 2006).
- SEIRS (susceptible, exposed, infected, recovered, susceptible) is formulated by transmission of harmful objects within the computer network with a mortality rate different from an attack of a harmful object and a mortality rate constant for infectious nodes. Death of a computer network node also means isolation of the node from the computer network, which carries on spreading harmful objects even if an antivirus software is operating constantly (Mishra et al, 2007).
- By extending the SEIRS model and implementing a new quarantine section, Mishra and Jha described the SEIQRS epidemic model. An undesirable file (such as a virus infected file or another harmful object) is moved by the quarantine to a folder that is not easily accessible by ordinary file ad-ministration tools (Mishra et al, 2010).
- The SEIQV (susceptible, exposed, infected, quarantined, vaccinated) epidemic model combines vaccination and dynamic quarantine methods (Wang et al, 2010).
- SLBS (uninfected computers, latent internal computers, breaking-out computers) is a computer model with a gradual treatment speed. It is a dynamic model characterizing computer virus spreading by the Internet, under two assumptions: (1) the computer has infectiousness as soon as it is infected, and (2) latent computers have lower treatment rate than attacked computers (Yang et al, 2013).

The current development in the area focuses on virus spreading in various conditions, when a large number of derived models have been proposed. These include mostly parameter optimization for the individual model situations and their dynamization.

(Chen et al, 2015) for instance, propose a delayed SLBS computer virus model. Using an optimal management strategy, they present an optimal strategy minimizing the total number of computer failures and costs related to toxication or detoxication. (Hong et al, 2015) proposed that node mobility in heterogeneous networks will affect the epidemic process. (Yun-Peng et al, 2017) proposed a dynamic information transfer model based on social impact elements. (Zhang et al, 2018) propose a new virus spreading model based on partial immunization and immune invalidity in a complex network. The new model is based on a combination of the SIS, SIR and SIRS models included in a partial loop of the model, the model is referred to as SISRS. Virus spreading in dynamic graph structure is discussed by (Pare Philip et al, 2018). The extended the studied SIS models to time-variable graphical structures and considered additional stochastic uncertainties. This extension makes the models more realistic an provides advanced knowledge on virus spreading on a larger scale of settings. (Li et al, 2019) examines threshold dynamics and ergodicity of the SIRS stochastic epidemic model with a disease transmission rate controlled by semi-Markov process. The semi-Markov process is used here for the description of randomly changing environment, which is very extensive.

2 Virus Spread Model

The mathematical models of space-time infectious disease spread help to reveal the causes of the disease origin and most often epidemic spread 1. Epidemiology employs models allowing the infection spread to be monitored during interactions among people present in a space or social network. A frequent goal is to establish the critical parameter values at which epidemics start spreading in the population. Apart from the usual use, the epidemiological models can also be used to model fundamentally close processes, such as fire spreading, plant invasion in unoccupied spaces, food chain dynamics, etc.

Let us start with the following virus dynamic model:

$$\frac{dS(t)}{dt} = \alpha - \beta S(t) - yS(t)I(t)$$
$$\frac{dI(t)}{dt} = yS(t)I(t) - \delta I(t) \qquad (1)$$
$$\frac{dR(t)}{dt} = \mu R(t) + \rho I(t)$$

where *S(t)*, *I(t)* and *R(t)* mark healthy cells, infected cells and free virus, constant α represents the level of cell regeneration, β, δ, μ mark the death rate of healthy cells, infected cells and free viruses. *Y* is a parameter of the degree of contact between healthy and infected population. $\frac{\rho}{\delta}$is the average number of viruses produced by one infected cell.

Since the behaviour of computer viruses is very similar to the behaviour of biological viruses, the computer virus spread model may be described as follows:

$$\frac{dH(t)}{dt} = \alpha - \beta H(t) - yH(t)I(t)$$
$$\frac{dI(t)}{dt} = yH(t)I(t) - (\vartheta + \beta)I(t) \qquad (2)$$
$$\frac{dC(t)}{dt} = -\beta C(t) + \vartheta I(t)$$

where *H(t)*, *I(t)* and *C(t)* are numbers of computers divided into three groups, at time *t*. *H(t)* is the number of healthy computers threatened by infection, *I(t)* is the number of infected computers and *C(t)* are "clean" computers from which viruses have been removed.

Constant α represents the speed of connection of external computers in the network, β is the speed of one computer removal from the network, υ is the speed of virus removal from one computer, γ is the speed of possible infection of a computer connected to the network.

3 Model Analysis

3.1 Positive Solution

For the model to make sense, all classes must be non-negative for each t≥0.

Clause 1

The solution of the (H, I, C) system (4) is positive for ∀t: t>0

Proof

a) Let us now assume that *H(t)* is not always positive, therefore there are t>0 for which H(t)≤0. Since the starting conditions (5) of the system (4) imply that at the start the solution t=0 is positive, there must be the lowest number t_1>0 that H(t_1)=0. If we substitute this value in the equation $\frac{dH(t)}{dt} = \alpha - \beta I(t) + \gamma I(t)H(t)$ the result is $\frac{dH(t_1)}{dt_1}$. With regard to the continuity *H(t)* there is η>0 that for $t \in (t_1, t_1 + \eta)$ it is H(t)<0. However, then for t_1 it is $\frac{dH(t_1)}{dt_1} = \alpha \leq 0$, which is disputable. Therefore for each t>0 there is H(t)>0.

b) For I(t) it may be derived from the equation $\frac{dI(t)}{dt} = yI(t)H(t) - (\vartheta + \beta)I(t)$ that $I(t) = e^{-(\vartheta+\beta)\upsilon} \times \left(\int_0^u \gamma e^{(\vartheta+\beta)} I(v)H(v)dv\right) > 0$

Thus I(t)>0 for each t>0.

Let there now be such t_2 that $C(t_2)=0$. After insertion in $\frac{dC(t)}{dt} = -\beta H(t) + \vartheta I(t)$, we get $\frac{dC(t_2)}{dt} = \vartheta I(t_2) > 0$. Analogically to (a), it may be derived that for each $t>0$ there is $C(t)>0$. Thus for system (2) it applies that its solution the (H, I, C) system is positive for ∀t: t>0

3.2 Equilibrium

Equilibrium refers to a constant differential equation solution. For our model this means that transfers might occur between the respective computer groups; however, their sizes remain constant over time. In general, there are two model equilibrium types: non-indicative, when the disease/infected computers disappear completely and the number of infected individuals is zero, and endemic, which is a state when the disease remains in the population but does not spread into an epidemic.

Equilibriums for our model can be calculated as:

$$E_0 = \left(\frac{\alpha}{\beta'} 0,0\right)$$
$$E_1 = \left(\tilde{H} = \frac{\vartheta + \beta}{\vartheta}, \tilde{I} = \frac{\beta}{\vartheta} \times \tilde{C}, \tilde{C} = -\frac{\alpha}{\vartheta \tilde{C}} + \frac{\beta}{\gamma}\right) \quad (3)$$

3.3 Numerical Experiment

Mathematic modelling is currently an integral part of various fields of natural, technical, economic and social sciences and an important instrument for modelling and simulations of systems, analyses and forecasting of their processes, phenomena, behaviour of species and states of societies. The use incorporates present information and communication technologies (ICT), in particular application mathematical software (e.g. Maple, Matlab). In this chapter, we will simulate various situations that can occur in computer networks and using suitable software, we will monitor the behaviour of the system in time.

3.3.1 Software Used

For calculation realization, we have selected Maple, which is a computer environment developed at the University of Waterloo in Canada, suitable for solving complex mathematical problems. It belongs to a group of computer algebra systems, allows solving of problems from various fields of mathematics from basics of linear algebra and mathematical analysis, differential and integral count to differential equations, geometry to logic. The system is aimed primarily for symbolic operations in mathematics, numerical calculations and graph displays. For the solution of ordinary differential equations, we will use the dsolve command and several related commands.

3.2.2 Example 1

A situation when a large portion of computers in the computer network have viruses. However, the network parameters reflect a situation when the network should gradually stabilize at E_0. As we can see in Fig. 1, the system positively converges to equilibrium.

Parameters: α=20; β=4; γ=1,2; d=2

Initial function values: H=20; I=10; C=1

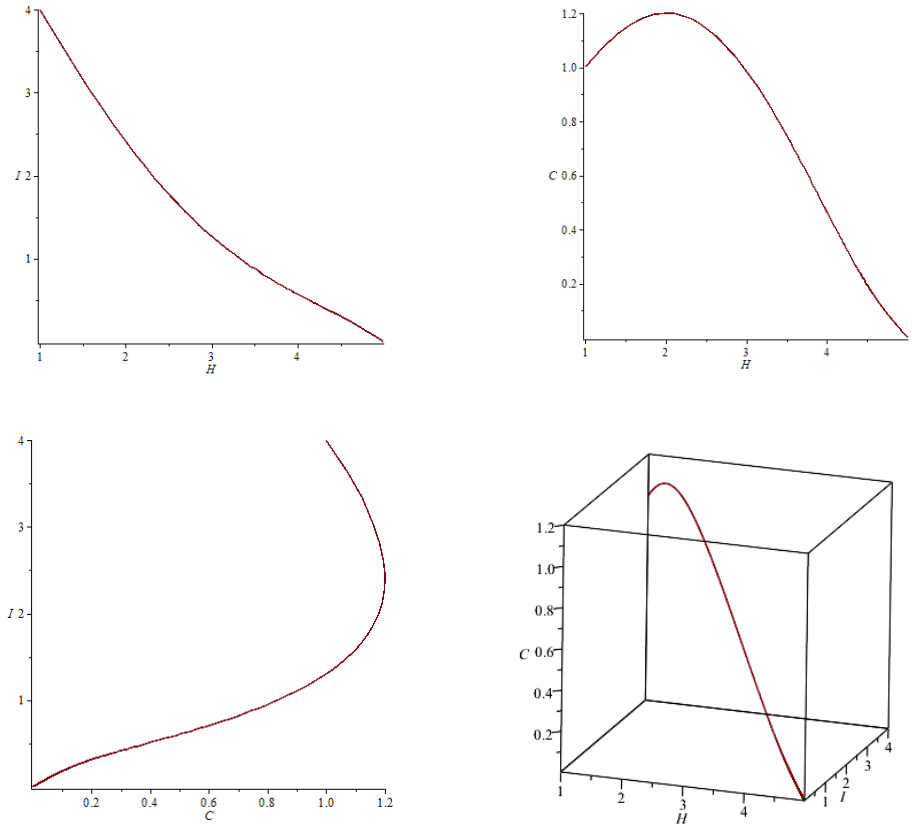

Figure 1 Example 1

3.3.3 Example 2

A situation when the majority of computers in the network are "healthy", only one computer is infected. The network parameters reflect a situation when the network should gradually stabilize at E_1. As we can see in Fig. 2, the system positively converges to equilibrium, as expected.

Parameters: $\alpha=4$; $\beta=0,3$; $\gamma=1,2$; $d=12$

Initial function values: H=12; I=1; C=0

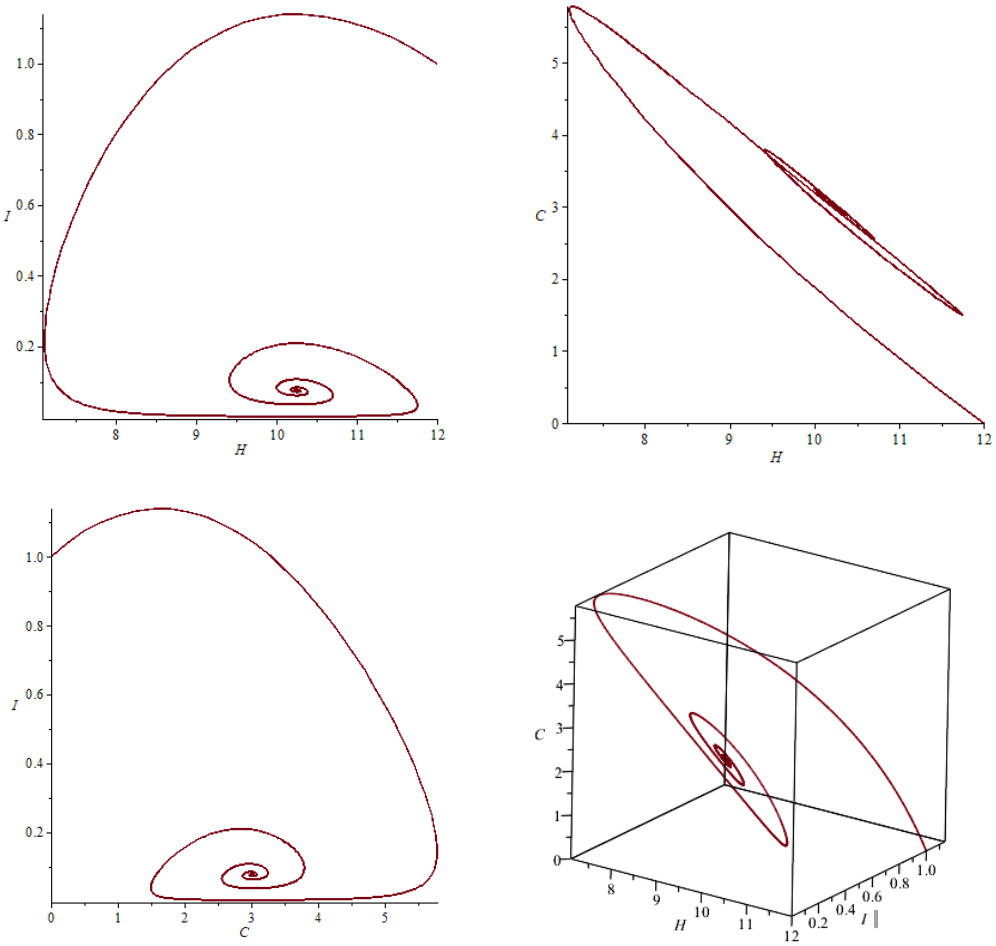

Figure 2 Example 2

3.3.4 Example 3

A situation when the majority of computers in the network are "healthy", only one computer is infected. The network parameters reflect a situation when the network should gradually stabilize at E_1. As we can see in Fig. 3, the system positively converges to equilibrium, as expected.

Parameters: α=4; β=0,3; γ=1,2; d=12

Initial function values: H=2; I=1; C=10

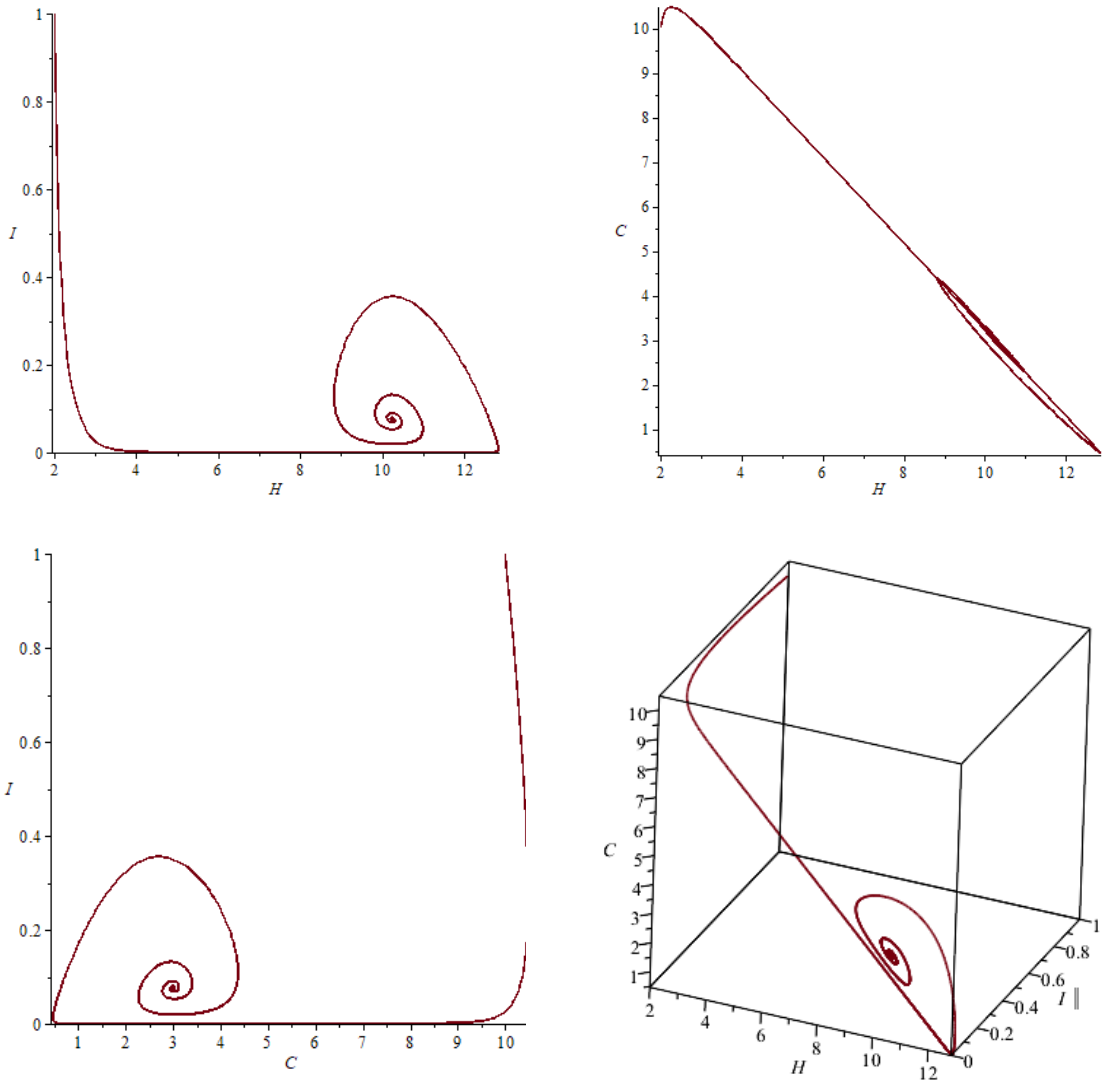

Figure 3 Example 3

Conclusion

Together with the increasing need to use computer technology and the increasing computer network integration, there is an increased risk of infiltration with one of the ever growing range of emerging viruses. Thus this danger should not be underestimated and computer data protection should be of the highest possible quality. If we understand how computer viruses can spread in computer network, it will be easier for us to decide what type of protection to choose.

References

BERNOULLI, D. (1760). *Essai d'une nouvelle analyse de la mortalité causé par la petite vérole et des avantages l'inoculation pour la prevenir*. Paris: Histoire de l'académie royale des sciences. Mémoires de mathématiques et de physique. Histoire de l'académie royale des sciences. p.1-45.

COHEN, F. (1987). Computer viruses: Theory and experiments. *Computers & Security*, 6(1), 22-35. Doi 10.1016/0167-4048(87)90122-2.

HONG, S., YANG, H., ZHAO, T., MA, X. (2015). Epidemic spreading model of complex dynamical network with the heterogeneity of nodes. *International Journal of Systems Science*, 47(11), 2745-2752. Doi 10.1080/00207721.2015.1022890.

CHEN, L., HATTAF, K., SUN, J. (2015). Optimal control of a delayed SLBS computer virus model. *Physica A: Statistical Mechanics and its Applications*, 427, 244-250. Doi 10.1016/j.physa.2015.02.048.

KEPHART, J. O., WHITE, S. R., CHESS, D. (1993). Computers and epidemiology. *IEEE Spectrum*, 30(5), 20-26. Doi 10.1109/6.275061.

KERMACK, W. O., McKENDRICK, A. G: (1927). A Contribution to the Mathematical Theory of Epidemics. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 115(772), 700-721. Doi 10.1098/rspa.1927.0118.

KERMACK, W. O., McKENDRICK, A. G. (1932). Contributions to the Mathematical Theory of Epidemics. II. The Problem of Endemicity. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 138(834), 55-83. Doi 10.1098/rspa.1932.0171.

LI, D., LIU, S., Jing'an CUI, J. (2019). Threshold dynamics and ergodicity of an SIRS epidemic model with semi-Markov switching. *Journal of Differential Equations*, 266(7), 3973-4017. Doi 10.1016/j.jde.2018.09.026.

MISHRA, B. K., JHA, N. (2010). SEIQRS model for the transmission of malicious objects in computer network. *Applied Mathematical Modelling*, 34(3), 710-715. Doi 10.1016/j.apm.2009.06.011.

MISHRA, B. K., SAINI, D. K. (2007). SEIRS epidemic model with delay for transmission of malicious objects in computer network. *Applied Mathematics and Computation*, 188(2), 1476-1482. Doi 10.1016/j.amc.2006.11.012.

PARE, P. E., BECK, C. L., NEDIC, A. (2018). Epidemic Processes Over Time-Varying Networks. *IEEE Transactions on Control of Network Systems*, 5(3), 1322-1334. Doi 10.1109/TCNS.2017.2706138.

THOMMES, R.W., COATES, M. J. (2005). Modeling Virus Propagation in Peer-to-Peer Networks. *IEEE*, 981-985. Doi 10.1109/ICICS.2005.1689197.

WANG, F., ZHANG, Y., WANG, CH., MA, J., MOON, S. J. (2010). Stability analysis of a SEIQV epidemic model for rapid spreading worms. *Computers & Security*, 29(4), 410-418. Doi 10.1016/j.cose.2009.10.002.

YANG, L.-X., YANG, X., ZHU, Q., WEN, L. (2013). A computer virus model with graded cure rates. *Nonlinear Analysis: Real World Applications*, 14(1), 414-422. Doi 10.1016/j.nonrwa.2012.07.005.

YAN, P., LIU, S. (2006). SEIR epidemic model with delay. *The ANZIAM Journal*, 48(01). Doi 10.1017/S144618110000345X.

YUN-PENG, X., SONG-YANG, L., YAN-BING, L. (2017). An information diffusion dynamic model based on social influence and mean-field theory. *Acta Physica Sinica*, 66(3), 030501/1-030501/13. Doi 10.7498/aps.66.030501.

ZHANG, X., WU, J., ZHAO, P., SU, X., CHOI, D. (2018). Epidemic spreading on a complex network with partial immunization. *Soft Computing*, 22(14), 4525-4533. Doi 10.1007/s00500-017-2903-1.

INVITATION

We kindly invite you and your colleagues to participate in Brno International Week 2019 (BIW 2019) that will be held during **October 14th – 17th 2019** at Brno University of Technology, Faculty of Business and Management in the Czech Republic.

Scope of the Brno International Week

The main aim of the International Week is to provide international mutual cooperation in the pedagogical, scientific fields and give an opportunity to our students to gain new perspectives on their majors. The focus of the BIW 2019 is on global issues in business, management, system engineering and informatics.

The Brno International Week will consist of three main parts:

1) **Guest lectures and seminars**: Each lecturer is invited to give one or two guest lectures or seminars lasting for two hours each. The main areas for lectures are:
    a. Economics and management
    b. System engineering and informatics
    c. Quantitative methods in economics

    We appreciate the lectures that combine theoretical background with practical implication or with international comparison and using modern teaching methods. We plan that the qualified contributions will be published in the faculty scientific journal or anthology.
2) **Round Tables:** We offer possibility to discuss your research ideas and mutual cooperation at Round Tables that will be thematic focused. Special Round Table will be arranged for Staff of International Offices.
3) **Movin´in:** You are cordially invited to present your home university and study programmes at the Movin´in where you can join the presentation of Erasmus students currently studying at our faculty.

BIW 2019 also aims at giving you an unforgettable stay in Brno. We invite you to an attractive social programme, including welcome drink with at the Rectorate of the university, guided city tour, wine, beer and food tasting in the local restaurant and a trip.

Please use the on-line Registration Form on https://biw.fbm.vutbr.cz/en. **Registration will be opened from May 15th till July 15th 2019**. For further information about BIW2019, please do not hesitate to contact us. **Contact person:** Zdenka Konecna, konecna@fbm.vutbr.cz

Project: CHEDTEB: Collaboration in Higher Education for Digital Transformation in European Business

KA2: Cooperation for Innovation and the Exchange of Good Practices

KA203: Strategic Partnerships for Higher Education

Duration:	09/2017 – 08/2019
Budget:	7 228 thousand CZK

Digitization is fast becoming a powerful driver of change in business and public life. Whilst the technologies in themselves are a major challenge for most European businesses, the underlying changes in company organisations, processes, skills requirements and business models are still, for most businesses, something of a white spot on the roadmap to the digital enterprise.

This project created a strategic partnership among three European universities: University of Tartu (Estonia), UAS Bielefeld (Germany) and Brno University of Technology (Czech Republic). The main aim is to provide the framework for a future joint master's degree on Digital Transformation of Corporate Business. Sharing interdisciplinary knowledge and skills of faculties, local corporate and institutional networks will enable universities and their local communities to bundle complementary resources, skills and ideas for digital transformation in order to:

- stimulate a common transnational learning process about 'Digital Transformation of Corporate Business' between local corporate networks and management faculties of universities by organizing workshops and showcasing best practice;
- set up an interdisciplinary Joint Degree program in 'Digital Transformation' by drawing specific resources from universities and combining them in a unique way in a common curriculum;
- inspire a heterogeneous cohort of international students by setting up an innovative curriculum based on modern didactic methods and in close co-operation with industry;
- blueprint a transnational pilot project in higher education which could serve as a model for the further institutional development of our universities.

The ambition of the project is not only to produce single-case materials but also to help activating the opportunities that lie in digital transformation for European businesses and society in general. All results are open-access items and are made publicly available, with reservations applying to strictly corporate intellectual property. For more information about CHEDTEB please join us at https://www.chedteb.eu.

CHEDTEB | Collaboration in Higher Education for Digital Transformation in European Business

Project: Digital Transformation for Business Models Innovations in small and Medium Sized Enterprises in the Czech Republic

Duration:	02/2019 – 01/2022
Budget:	4 977 thousand CZK
Organizations:	Brno University of Technology (coordinator)
	Institute of Technology and Business in Ceské Budejovice
	Association of Small and Medium-Sized Enterprises and Crafts CZ
	Research Institute for Entrepreneurship and Innovations

The project aims at strengthening the innovative capacity, competitiveness, sustainability and level of digitization of SMEs.

The goal of the project is to prepare the certified methodology and software based on development of methods, models and tools of the digital transformation to support innovation capacity and increase the level of competitiveness of business models for SMEs.

It enables SMEs:

- to evaluate a level of digital maturity,
- to increase innovation activity,
- to generate sustainable value creation for customers,
- to apply the implementation of digital transformation to business models,
- to increase company performance,
- to accelerate the learning process and the development of competencies in the business models and digital transformation, and
- to internationalize.

The project reg. no. ***TL02000215*** is funded by the ***Technology Agency of the Czech Republic***, *programme ETA*.

For more information about the project please contact assoc. prof. Iveta Simberova (simberova@fbm.vutbr.cz)

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