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Fakulteta za organizacijske vede

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INTERNACIONALIZACIJA IN SODELOVANJE

INTERNATIONALIZATION AND COOPERATION

Proceedings of Selected Papers
of the 34th International Conference
on Organizational Science Development

Foreword

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Foreword

From 25th to 27th March 2015, the University of Maribor, Faculty of Organizational Sciences hosted its 34th International Conference on Organizational Science Development called “Internationalization and Cooperation”, which took place in Portorož, Slovenia. We accepted 140 papers and 6 posters from 233 authors and co-authors, coming from Slovenia and the following foreign countries: Albania, Bosnia and Herzegovina, Czech Republic, Croatia, Germany, Greece, Hungary, Montenegro, Serbia, and Slovakia.

In order to strengthen the Conference’s scientific flavour, increase its recognition, and give an extra reward to the best submitted papers, we have decided to publish Selected Papers, a special issue of the Conference Proceedings. This publication contains 22 papers in English, which have been carefully selected among all the accepted conference papers by the Conference Review Committee.

I congratulate the authors of all 22 selected papers, and thank the members of the Review Committee for their efforts. I hope that the Selected Papers issue will achieve its aims.

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34th International Conference on Organizational Science Development
INTERNATIONALIZATION AND COOPERATION
March 25th – 27th 2015, Portorož, Slovenia

The Analysis of Pension Funds' Bond Portfolio in the Republic of Croatia

Mihovil Anđelinović
University of Zagreb, Faculty of Economics and Business, Croatia
mandelinovic@efzg.hr

Drago Jakovčević
University of Zagreb, Faculty of Economics and Business, Croatia
djakovcevic@efzg.hr

Margareta Maresić
University of Zagreb, Faculty of Economics and Business, Croatia
margareta.maresic@gmail.com

Abstract

During the recent economic crisis, various risks related to the investment policies of pension funds have been enhanced due to the substantial negative trend in the global capital markets. The main objective of this paper is to determine to what extent the share of debt securities in the pension fund portfolio and changes in their market prices have impact on business performance and returns of mandatory pension funds in Croatia. In the focus of the analysis of bond portfolio are Croatian government bonds. The correlation between MIREX and CROBIS indices is quantitatively determined by linear regression model. The paper, both from theoretical and statistical point of view, analyzes the modalities of yields and methods of hedging the pension fund's assets from the risk of negative or insufficient yield. The results of the regression analysis provide an answer to the question whether the change in the structure of the pension funds' portfolio, which could be achieved by changing the legislative framework and restrictions on investments in favor of the other financial instruments, particularly those from foreign capital markets, is necessary. The authors provide a coherent conclusion as the guidance of external constraints in order to achieve financial sustainability of the Croatian pension system. The paper is primarily in function of forecasting future dynamics and, on that basis, it could serve as guideline in an introduction of changes in the structure of pension fund portfolios.

Keywords: Croatian pension system, pension funds' efficiency, debt securities, investment portfolio, regression analysis

1 Introduction

Pension funds are the most significant and, by value of assets, leading institutional investors in the Republic of Croatia. Their demand increases the number of transactions in the financial

markets, encourages a creation of new instruments and, by size and structure of investments, they are becoming, directly or indirectly, business owners as well as important creditors of the economy and the state. The rapid growth and amount of the assets which pension funds have is increasingly attracting interest of general public, while on the other hand funds have been more frequently involved in political and social upheavals. The paper analyzes a bond portfolio of pension funds in the Republic of Croatia in order to determine exposure to debt securities, with particular focus on Croatian government bonds and the impact of bond portfolio to the overall business operations of funds.

In Croatia, until about ten years ago, there has only been a public pension system of intergenerational solidarity and defined benefit scheme so costs for current pensions were mostly financed from contributions paid by employees. Aging of population in developed countries has a strong influence on the current state and future of pension systems. On December 31, 2013 a total of 1.190.815 pension beneficiaries (2.21% less than in December 2012) and 1,400,631 insured persons were registered, which makes the ratio of 1:1.18. The equal ratio was recorded in 2012, which represents worse condition than in the previously observed years. Specifically, the ratio of pensioners and employed people was 1:1.30 in 2009, 1:1.23 in 2010, and 1:1.21 in 2011 (HZMO, 2013).

Since 2002, the reformed pension system in Croatia has been based on three pillars of pension insurance:

1. mandatory pension insurance based on intergenerational solidarity;
2. mandatory pension insurance based on individual capitalized savings;
3. voluntary pension insurance based on individual capitalized savings.

The first pillar is mandatory pension insurance based on intergenerational solidarity. All employees insured in this pillar, by the force of law, set aside 15% of gross salary, which goes to the pension fund of the Croatian Pension Insurance. These funds are used for paying pensions of current retirees. The second pillar is mandatory pension insurance based on individual capitalized savings, which is the subject of the analysis in this paper. From the gross salary of each insured, a 5% contribution is paid to pension funds which the insured person has chosen. The insured person is, at any time, allowed to change the mandatory pension fund, if one is dissatisfied with the service. When becomes eligible for retirement, the insured chooses the pension insurance company and transferres its capital from pension fund which he or she had previously been a member of, and signs an agreement on the payment of pensions with the chosen pension insurance company. The third pillar refers to voluntary pension insurance system based on individual capitalized savings. The amount of the pension is determined by the height of monthly roles that are paid into a special account in the voluntary pension fund. The pension fund invests the accumulated money in the market and makes profit that is added to savings of the insured person. (Baković, 2013; Puljiz, 2011) Table 1 shows the changes of assets of financial institutions in Croatia and the share in total assets at the end of 2002, 2012 and 2013.

It is apparent that the share of banks in total assets of financial institutions in the period was significantly reduced. The share of banks in 2002 was 86.9%, while in 2013 it decreased to 72.8% of total assets.

	2002.		2012.		2013.	
	Amount	Share	Amount	Share	Amount	Share
Credit institutions						
1. Banks	174.122	86,9	399.888	73,9	398.118	72,8
2. Savings banks	-	-	27	0,1	16	0,1
3. Housing savings banks	2.186	1,1	7.456	1,4	7.561	1,4
Insurance companies and pension funds						
4. Insurance and reinsurance companies	11.097	5,5	34.050	6,3	35.799	6,5
5. Mandatory Pension Funds	2.037	1,1	51.134	9,4	58.238	10,6
6. Voluntary Pension Funds	3	0,1	2.429	0,4	2.703	0,5
Other financial intermediares						
7. UCITS funds	2.463	1,2	12.962	2,4	13.257	2,4
8. Fund for Croatian Homeland War Veterans and Their Families	-	-	1.134	0,2	972	0,2
9. AIF funds	1.202	0,6	2.140	0,4	1.869	0,3
10. Leasing companies	7.149	3,6	22.237	4,1	19.732	3,6
11. Factoring companies	-	-	7.212	1,3	7.987	1,5
12. Credit unions	-	-	602	0,1	660	0,1
TOTAL	200.259	100	541.271	100	546.912	100

Table 1: Assets of financial institutions in Croatia and their share in total assets in the period from 2011 to 2013 (in millions HRK and %).
Source: Authors according to HANFA data

During the observed period, the share of pension fund assets in total assets rose to 10.4%, which is, in comparison with other financial intermediaries, the highest growth in market share.

1.1 Regulatory framework and pension fund asset allocation

To ensure favorable risk-return ratio, management function of the pension funds must be set up and governed responsibly. Therefore, the key role of the legislator is to ensure that the regulatory framework encourages responsible fund asset management and, in that, to achieve the objectives of pension plans and the pension system. This indicates the importance and necessity of regulation of pension funds´ business activities and the introduction of an adequate legislative framework. The legal provisions may include maximum levels of investment by category (ceilings) to the extent that they are consistent with and promote the prudential principles of security, profitability, and liquidity pursuant to which assets should be invested. Legal provisions could also similarly include a list of admitted or recommended assets. (OECD, 2006)

A list of all legal constraints, which actually represent the explication of the diversification principle, are located in the Law on Compulsory and Voluntary Pension Funds. The latest amendments of Law in 2014, which are partly influenced by the relevant EU legislation mainly in the field of financial services and free movement of capital, extended the possibility of investments of mandatory pension funds in certain asset classes. It is crucial to state that the insured individuals were given the right to choose between three categories of mandatory funds that precisely differ by allocation restrictions and by risk apetite and possible yield. Table 2 presents below some of the most important allocation restrictions of each category of mandatory pension funds in Croatia. In order to safeguard pension funds and avoid risky investments, the law stipulated that most of the assets shall be allocated in government bonds, i.e. securities guaranteed by the Republic of Croatia. Permitted investments of pension fund assets are defined in a way that the safety of an asset is always in the forefront so that all

speculative and high-risk investments are prohibited. Speaking of foreign capital markets, pension funds may allocate funds only in the securities of issuers from the another member state of the European Union or an OECD member. From July 1, 2013, i.e. from the date of Croatian accession to the European Union, there are no quantitative restrictions on the allocation in foreign assets originating from the above countries and integrations.

Asset classes	A category	B category	C category
1. net fund assets in bonds and money market instruments of the Republic of Croatia, EU members or OECD countries	min 30%	min 50%	min 70%
2. net fund assets in bonds and money market instruments guaranteed by te Republic of Croatia, EU members or OECD countries or the issuer is an international authority that encompasses one or more EU members or OECD countries	max 30%	max 30%	max 10%
3. net fund assets invested in bonds and money market instruments issued by a local and regional government from the Republic of Croatia, another EU member or OECD country	max 30%	max 30%	max 10%
4. net fund assets invested in bonds and money market instruments, whose issuer is headquartered in the Republic of Croatia, another EU member state or OECD country, taking into account the indirect exposure via UCITS funds and financial derivatives	max 50%	max 30%	max 10%
5. net fund assets in shares of the issuer from the Republic of Croatia, EU members or OECD countries, including also the indirect exposure through UCITS funds and financial derivatives	max 55%	max 35%	investment in shares is not permitted; indirect exposure via UCITS funds and financial derivatives max 10%
6. net fund assets must invested in the assets which are traded or which are settled in kuna	min 40%	min 60%	min 90%

Table 2: Allocation restrictions for each category of mandatory pension funds
Source: Mandatory Pension Funds Act (Official Gazette 19/14)

Pension fund investments are generally regulated by comprehensive investment limit structure that determines the types of instruments in which pension funds can invest and their respective thresholds. Allocation in securities and money market instruments allowed by the Law, along with taking into account the prescribed investment restrictions, ensure the quality and profitability of the entire fund portfolio while maintaining adequate liquidity and reduction of risk. Table 3 shows the structure of pension fund investments in the period from 2008 to June 2014. In the asset structure of mandatory pension funds, consisting of domestic and foreign assets, the domestic assets dominated with a share of 87%, i.e. 54.3 billion kuna.

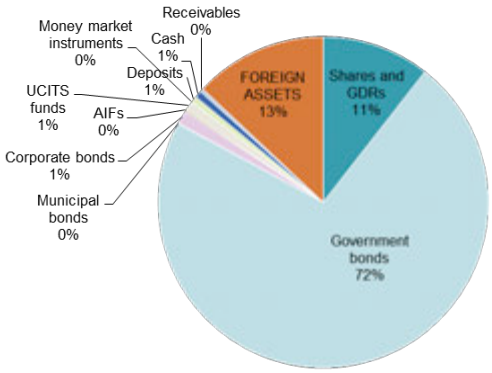
Type of assets	12.2008.	12.2009.	12.2010.	12.2011.	12.2012.	12.2013.	06.2014
DOMESTIC ASSETS	**20.920.792**	**26.572.709**	**32.580.847**	**36.473.475**	**45.095.783**	**51.383.668**	**54.322.635**
Shares and GDRs	2.529.825	3.909.073	5.740.135	5.748.319	6.549.773	6.631.050	6.595.624
Government bonds	15.937.982	16.716.518	23.776.543	27.179.292	33.335.063	40.131.639	45.164.160
Municipal bonds	81.448	79.044	73.539	41.348	35.275	29.850	24.688
Corporate bonds	732.269	1.108.541	1.219.992	1.282.334	1.298.598	1.190.935	818.027
AIFs	56.909	69.272	67.927	21.869	16.396	7.891	121.088
UCITS funds	373.285	1.031.757	550.914	1.033.923	896.621	1.511.299	577.312
Money market instruments	290.562	2.025.358	349.407	113.073	986.669	305.702	4.999
Deposits	631.543	1.242.256	617.655	683.459	1.194.854	356.643	383.032
Cash	265.500	375.189	111.361	228.283	531.306	600.525	427.609
Receivables	21.470	15.700	73.372	141.574	251.228	618.134	206.096

FOREIGN ASSETS	**1.696.084**	**2.790.856**	**4.348.910**	**4.739.356**	**6.077.571**	**7.459.949**	**8.121.619**
Shares and GDRs	481.446	763.268	1.858.651	2.909.502	3.649.881	4.609.803	4.883.274
Government bonds	307.489	1.253.393	444.719	213.552	252.801	564.425	640.212
Municipal bonds	0	0	0	0	0	0	0
Corporate bonds	475.845	60.764	49.968	1.503	1.574	0	0
AIFs	0	0	0	0	0	0	0
UCITS funds	431.303	713.432	1.995.571	1.614.799	2.173.314	2.285.722	2.598.133
Money market instruments	0	0	0	0	0	0	0
Deposits	0	0	0	0	0	0	0
TOTAL ASSETS	**22.616.876**	**29.363.566**	**36.929.757**	**41.212.831**	**51.173.354**	**58.843.617**	**62.444.254**
Net assets	**22.590.933**	**29.264.636**	**36.328.054**	**41.067.099**	**51.133.725**	**58.237.703**	**61.388.121**

Table 3: Pension fund asset allocation from 2008 to June 2014 (in thousands HRK).
Source: Authors according to HANFA data

It can be seen that the share of allocation in domestic assets in the period from 2008 to 2013 continuously decreased in favor of reallocation in foreign assets which have, during the observed period, increased five times and, according to the latest data from June 2014, have taken up a share of 13% of portfolio. Domestic assets of pension funds were mostly allocated in domestic government bonds, while foreign investments are mainly represented by shares and investment funds.

Traditionally, mandatory pension funds have mostly allocated their funds in Croatian government bonds that had a share of 72.33% of total assets, i.e. 45.16 billion, which represents a slight increase, compared to the year 2012 (when the share of state bonds was 68.2%). In the observed period, investments in mentioned securities have increased year after year. On the other hand, the funds that were allocated in foreign bonds had a share of only 1.03% of the total amount of net assets (i.e. 640 million).

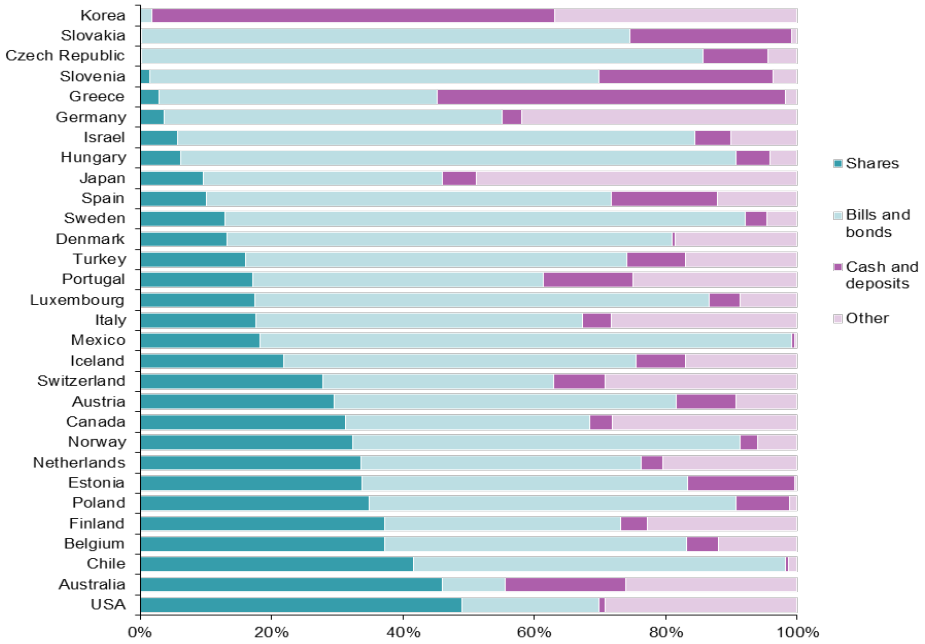


Graph 1: Mandatory pension fund asset allocation in June 2014 (as a % of total investment).
Source: Authors according to HANFA data

When analyzing the structure of pension fund investments in Croatia, it should be considered that one of the limiting factors in portfolio structure (except legal restrictions) is lack of high quality financial instruments in the financial market and there is a very limited number of securities for funds to invest in. So, the major problem is narrow and undeveloped market where there are not many "good" and safe securities in which the large amount of pension funds' assets could be allocated in. In Croatia, from July 1, 2013, i.e. from the date of EU accession, quantitative restrictions on investment in assets of the Member States of the OECD

and the EU have been abolished, whose financial markets are generally more developed than Croatia's, which leads to a partial solution of this problem. Even though not much time has passed since that date, the investment policy has not still adapted to the new legal legislative changes and Croatian pension funds have not yet experienced drastic changes and redistribution of assets within their portfolios, which does not mean that, in medium and long run, the portfolio structure picture will not be significantly altered.

In order to compare the structure of Croatian pension funds' investments with those from comparable countries, with more or less developed financial markets, follows the analysis of the structure of pension funds' investments in selected OECD countries in 2012. As Graph 2 shows, in most OECD countries, for which 2012 asset allocation figures were available, bonds and equities were the two most important asset classes in which pension funds invested in 2012.



Graph 2: Pension fund asset allocation for selected investment categories in selected OECD countries in 2012 (as a % of total investment).
Source: Authors according to OECD data

Thirteen OECD countries invested more than 80% of their portfolio into these two asset classes at the end of 2012. The United States allocated the biggest share of their portfolios in shares in 2012 (48.9% of total investments), and is followed by Australia (46.0% of total investments) and Chile (41.6% of total investments). In these three countries, pension funds' equity allocations were above the OECD weighted average of 40.3% of total investments. In over half of the OECD countries, pension funds invested more than 50% of their assets in bills and bonds in 2012. The proportion of bills and bonds in pension fund portfolios was over 80% in three countries, namely the Czech Republic (85.4%), Hungary (84.6%) and Mexico (80.9%). Moreover, bills and bonds were more than 50% of the portfolio in 2012 in 14 OECD countries and the greater preference of bills and bonds investments might reflect the turning towards fixed income products in order to safeguard minimum guaranteed returns (e.g. mutual pension funds in Slovenia), or it can be associated with higher yields on bills and bonds in some countries, for example Spain. However, as shown in Graph 2, in most OECD countries

the pension funds tended to reduce the share allocated to bills and bonds and reallocate part of this share to equities. Between 2011 and 2012, among the observed OECD countries, which saw a decrease in the allocation to bills and bonds, the biggest reallocation to equities was performed by Mexico (5.8 pp.) and Poland (4.1 pp.).

A departure from traditional investment products (i.e. shares, bills and bonds, cash and deposits) to other kind of assets has been observed in 2012 in approximately a third of OECD countries. The mentioned "Other" category, which includes notably loans, land and buildings, unallocated insurance contracts, hedge funds, private equity funds and structured products, can be deemed as alternative assets. It was mainly composed of land and buildings in Finland, Portugal, Switzerland; loans in Germany; and of unallocated insurance contracts in Italy and Korea. (OECD, 2013)

2 The analysis of pension funds' bond portfolio

In this section of paper, the authors have elaborated on the impact of one factor, reasonably considered important, on the movement of the performance index of mandatory pension funds. In the structure of pension fund investments is shown that government bonds have dominance of their portfolio and currently have share of around 72%. This leads to particular interest in observing interactions of CROBIS and MIREX indices. Looking at the structure of pension fund investments, the question to what extent the share of debt securities in the pension fund portfolio and changes in their market prices have impact on yields of mandatory pension funds in Croatia, is raised.

The aim is to find an analytical solution by using a regression model, which will quantitatively express whether and to what extent is movement and tendency of MIREX connected with the values and changes of CROBIS. The results are primarily in function of forecasting future dynamics and, on that basis, they could serve as guideline in an introduction of changes in the structure of pension fund portfolios.

2.1 Variable selection

Linear regression is an approach for modeling the relationship between a scalar dependent variable y and one or more explanatory, independent variables denoted x. The data is modeled using linear predictor functions, while unknown model parameters are estimated from the data and such models are called linear models. In this case, a simple linear regression model has been applied. (Freedman, 2009; Seal, 1967) The case of one explanatory variable is called simple linear regression. The selected dependent variable of primary interest, or a variable that is going to be described is the monthly change in % of index of mandatory pension funds MIREX (y), while the explanatory variable is monthly change in % of bond index CROBIS (x).

The MIREX index is the average value of accounting units of all mandatory pension funds calculated as the weighted arithmetic mean, with weight representing the share of a simple mandatory pension fund in the total net assets of all mandatory pension funds of the same category. The MIREX index represents the measure of a pension fund performance and it shows values of four mandatory pension funds (PBZ Croatia fund, AZ Fund, Raiffeisen Fund and Erste Plavi), and the index enables a comparison of business performance and investments of each pension fund. Hence, the index represents the work of the entire industry and shows its average values so the interpretation of regression results is simpler and more transparent.

CROBIS is the Zagreb Stock Exchange bond index whose publishing began on October 1, 2002. The base date is September 30, 2002 and the base index value on the base date was at 100 base points. The index is weighted by bond market capitalisation, with the weighting of any individual bond issue in the index limited to 35% of the capitalisation.

2.2 A simple linear regression model with MIREX and CROBIS variables

Table 4 shows monthly changes of bond index CROBIS and MIREX index in the period from January 2010 to July 2014. For the purpose of research, 55 monthly changes for each of the selected variables have been chosen in the sample. The sample includes only the period from 2010 to 2014 because it provides an objective glance, and takes precedence over a sample from the earlier period. In case that data from previous years was joined to the sample (2007 to 2010), the results would significantly differ from the obtained ones because of the substantial influence of the world financial crisis which resulted in significant distortions in the markets. Based on this data, which would be influenced by a large number of negative and unusual factors, reliable conclusions could not have been made.

	2010.		**2011.**		**2012.**		**2013.**		**2014.**	
	MIREX	CROBIS	MIREX	CROBIS	MIREX	CROBIS	MIREX	CROBIS	MIREX	CROBIS
1.	1,83%	1,48%	1,66%	-0,26%	0,83%	-0,92%	2,49%	0,87%	0,45%	0,55%
2.	0,05%	0,74%	0,05%	0,09%	1,09%	1,34%	-0,15%	-1,51%	2,62%	1,69%
3.	1,66%	-0,98%	1,16%	1,51%	0,83%	2,54%	0,32%	-0,69%	-0,06%	-0,08%
4.	0,21%	0,49%	0,16%	0,64%	1,01%	1,26%	1,03%	1,04%	0,15%	0,82%
5.	-0,75%	-0,26%	1,27%	0,62%	-0,59%	0,40%	-0,69%	-0,44%	1,97%	1,20%
6.	-1,14%	-1,13%	-0,42%	-0,01%	0,68%	0,24%	-2,23%	-2,11%	1,65%	1,68%
7.	1,33%	-0,17%	-0,21%	-2,08%	1,50%	0,09%	2,30%	1,33%	0,61%	-0,79%
8.	1,15%	0,31%	-1,89%	-1,47%	0,56%	1,13%	-0,06%	-1,49%		
9.	1,14%	0,02%	-1,58%	-0,92%	3,31%	5,05%	0,51%	-0,35%		
10.	0,75%	-0,10%	0,63%	-1,40%	1,75%	1,23%	0,29%	-0,06%		
11.	0,33%	-0,46%	-1,65%	-2,38%	0,46%	-0,13%	0,57%	-0,49%		
12.	1,81%	-0,17%	1,43%	1,10%	0,32%	0,80%	0,08%	-0,56%		

Table 4: Monthly changes of MIREX and CROBIS indices from January 2010 to July 2014.
Source: Authors' calculations on HANFA and ZSE data

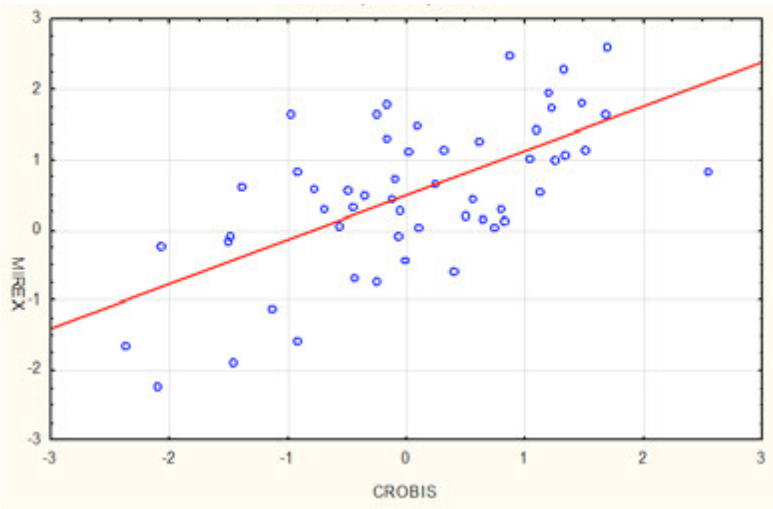
Obviously, stated indices have had a very similar trend during the observation period. Moreover, a considerable volatility of indices is noticeable on a monthly basis. When comparing the listed standard deviations, it can be concluded that in this period the monthly change of CROBIS has had a greater volatility of monthly change of MIREX. The values obtained by descriptive statistics analysis are shown in Table 5.

	Descriptive Statistics							
Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.
MIREX	55	0,592029	0,570000	-2,23000	3,310000	1,267416	1,125796	190,1590
CROBIS	55	0,161255	0,020771	-2,37915	5,052034	1,592473	1,261932	782,5691

Table 5: Descriptive statistical values (mean, median, minimum, maximum, variance, standard deviation and coefficient of variation) for the values of MIREX and CROBIS
Source: Authors' calculations

Determination of a correlation between variables by using a scatter diagram

The first step in the regression analysis was creating a scattering diagram in order to spot existence or non existence of correlation between two phenomena and to define its tendency and strength. (Dumičić, Bahovec, 2011) The following scattering diagram shows the nature of relations between variables MIREX and CROBIS. The points on the diagram are determined with set of values of the observed quantitative variables. One monthly yield of independent variables and the pertaining pair were identified as an outlier so, in the creation of diagram, this point was excluded. In the distribution of points in the diagram the existance of positive statistical relationship it is apparent where the increase in value of the variable CROBIS leads to an upward trend of the value of MIREX index.



Graph 3: Scatter diagram of variables MIREX and CROBIS
Source: Authors' calculations

The regression parameters estimation

After looking at the scattering diagram it can be concluded that the relationship between MIREX and CROBIS index linear (because the spots were distributed close to some preconceived line) and has got a positive trend. It is justified to assume that the correlation of monthly returns of the two indices can be described by the model $y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$. To determine the estimated model $\hat{y}_i = \hat{\beta}_0 + \hat{\beta}_1 x_i$, it is necessary to determine the values of regression coefficients. There are different methods of estimating parameters and most commonly used are the ordinary least-squares method, method of moments and maximum-likelihood (Šošić, 2004). In this paper, the parameters of the regression model, the constant term $\hat{\beta}_0$ and the regression coefficient have been estimated by the least-squares method. By using the given sample, and with the assistance of Statistica software, the following estimated regression equation has been obtained:

$$\hat{y}_i = 0{,}4947 + 0{,}6137x$$

Specifically, the interpretation of $\hat{\beta}_1$ is the expected change in y for a one-unit change in x_j when the other covariates are held fixed—that is, the expected value of the partial derivative of y with respect to x_j. Based on the regression model, the regression coefficient indicates that the monthly return index MIREX increases by 0.63%, in case of 1% change in monthly yield of CROBIS. Constant is 0.4967 and, in this case, a specific interpretation is not neccessary (theoretical value indicates the regression value of MIREX index if a yield of

CROBIS was zero). The following table shows the results of regression equation calculation by Statistica software.

N=55	Regression Summary for Dependent Variable: MIREX (Regresija) R= ,68789485 R²= ,47319933 Adjusted R²= ,46325969 F(1,53)=47,607 p<,00000 Std.Error of estimate: ,82479					
	b*	Std.Err. of b*	b	Std.Err. of b	t(53)	p-value
Intercept			0,493069	0,112135	4,397091	0,000053
CROBIS	0,687895	0,099698	0,613685	0,088942	6,899805	0,000000

Table 6: Regression summary for variables MIREX and CROBIS
Source: Authors' calculations

2.3 Correlation coefficient of monthly changes of MIREX and CROBIS indices

After graphical presentation of the correlation of monthly returns between the two variables, follows the quantitative determination of their connection. In statistics, the Pearson product-moment correlation coefficient (sometimes referred to as the PPMCC or PCC or Pearson's r) is a quantitative measure of the linear correlation (dependence) between two variables X and Y. The measure of linear correlation between two variables is covariance. Pearson's correlation coefficient between two variables is defined as the covariance of the two variables divided by the product of their standard deviations. The form of the definition involves a "product moment", that is, the mean (the first moment about the origin) of the product of the mean-adjusted random variables; hence the modifier product-moment in the name. The coefficient of simple linear correlation can have a value between +1 and −1 inclusive, where 1 is total positive correlation, 0 is no correlation, and −1 is total negative correlation. As the correlation coefficient comes closer to 1 or -1, grows the correlation between two variables. Table 7 shows the values of coefficient and related interpretations (Dumičić, Bahovec 2011).

r	Interpretation
0	absence of correlation
0 – (±0,5)	weak positive / negative correlation
(±0,5) – (±0,8)	medium positive / negative correlation
(±0,8) – (±1)	strong positive / negative correlation
±1	absolute positive / negative correlation

Table 7: Interpretation of Pearson's correlation coefficient values
Source: Dumičić, K. i Bahovec, V. (2011) Poslovna statistika

The linear correlation coefficient is linked to the linear regression model. Specifically, it is closely related to the coefficient of determination and therefore, in this paper, is calculated using the regression model. The correlation coefficient between monthly changes of CROBIS and MIREX indicates medium strong, positive relationship and its estimation is:

$$r_{MIREX,CROBIS} = 0{,}687894854$$

The following table shows summary of regression and correlation analysis of variables MIREX and CROBIS.

	Summary Statistics
Statistic	Value
Multiple R	0,687894854
Multiple R^2	0,47319933
Adjusted R^2	0,463259694
F(1,53)	47,6073131
p	0,0000000065382233
Std.Err. of Estimate	0,824786824

Table 8: Summary of regression and correlation analysis of variables MIREX and CROBIS
Source: Authors' calculations

From the regression analysis of monthly changes of index MIREX and CROBIS in the period from January 2010 to July 2014 and quantitative analysis of the correlation between them, it is evident that the Croatian mandatory pension funds have been highly influenced by price changes of government bonds, which has reflected on their returns. In fact, the change of a price of these securities in the market and the yield of mandatory pension funds on average had the same trend. The obtained quantitative values (more precisely, the correlation coefficient is 0.68789), regarding to the previous analysis of the portfolio structure of pension funds, are not surprising. The observed interaction can be primarily attributed to fund management and regulatory frameworks that have recently been in force. In case that a sample from the previous few years was included in the research, the results would give a different picture of the condition on the market. The correlation coefficient for monthly returns from 2006 to 2014 amounted to 0.59801, which can be attributed to the influence of the crisis, which have not only altered money and capital flows in the financial markets, but also affected a stability of the economy as a whole.

As regulation allows investments in shares at a much higher scale than their current share in portfolio is a policy of pension funds could be described as extremely passive. Legal requirements are no longer an obstacle to the construction of the optimal portfolio and it should be noted that their recent changes solved the problem of limited Croatian capital market also. Moreover, with the portfolio restructuring in order to solve the problem of relatively low yields of funds and their large exposure to government bonds and the associated risks, it is recommended to move away from the passive investment policy focused almost exclusively on the domestic market. However, from the chronological outline of investments (see Table 2), an increase in the share of foreign assets has been noticed, but in the low extent.

Given that the foreign capital market offers a wide range of debt and, especially, equity securities, the implementation of diversification could move in that direction. During volatility periods in the market, value of a portfolio that includes investments in bonds and shares may could not reduce in the extent as the value of the one that consists of shares or bonds only. There is no "one-size-fits-all" default investment strategy but some, such as those with low exposure to equities (less than 10%) and those with overly high exposure to equities (more than 80%), generally proved inefficient. (Antolin, P., Payet, S. i Yermo, J., 2010). Effective diversification requires much more than a random inclusion of different asset classes in portfolio. Fund management, at the same time, carefully measures financial instruments and sets out the advantages and disadvantages of allocation alternatives, along with a detailed analysis of potential yields and the risks that a particular security bears. In case of bonds, the principal protection can be achieved by focusing on higher quality debt instruments and implementation of diversification policies based on assesments of bond issuer, maturity and credit rating (Chorafas, 2005).

3 Conclusion

In the analysis of pension fund investment portfolio, it was concluded that the raised funds of mandatory pension funds were traditionally mainly allocated in Croatian government bonds, which initiate a special interest for studying the influence that government bond prices have on mandatory pension fund yields. The scatter diagram showed a positive correlation between the variables CROBIS and MIREX, while the simple linear regression model quantitatively expressed the extent to which monthly return index MIREX is correlated to the value and changes of CROBIS. Linear correlation between monthly changes of the two indices is 0.68789, which indicates medium strong and positive relationship. Based on the calculations, it can be concluded that, during the observed period, monthly returns of mandatory pension funds were heavily influenced by changes in prices of government bonds issued by the Republic of Croatia. It follows that pension funds' business activities in Croatia are significantly influenced by the fact that, according to the latest estimates of the key rating agencies, Croatia is classified into a speculative class. Possible additional distortion of already fragile confidence of investors in the Croatian economy because of potential further credit rating downgrades could result not only with the serious economic but also social consequences.

Obtained statistical values, taking into account the graphic and descriptive analysis of the asset allocation of the pension funds, are not surprising and estimated interdependence can be attributed primarily to fund management and legislative framework. But a major problem that arises is investment restrictions and narrow limited market that does not offer enough quality and safe securities in which this volume of pension funds' assets could be invested in. Although EU member states and OECD have abolished quantitative restrictions on investments in foreign assets, pension funds (most likely due to the short period of time from the changes of the Law passed) have not significantly change the image of their portfolio.

It is recommended to change that in order to create an optimal portfolio of pension funds, relying on one of the basic investment principles - diversification. Moreover, the re-structuring of portfolio should move away from passive policies which focus is almost exclusively on the domestic market of debt securities. Changes in the investment structure are expected in the middle-, especially in the long term, with the higher yields, and also greater portfolio security expectations. Consequently, the above changes will have a significant impact on pension levels and living standards of retired people, but also on the economy as a whole. The phenomenon of population ageing, occurring in many developed countries across the world, has resulted in the shift in traditional understanding of the role of state in the economics of pension. Results of analysis of bond portfolio of pension funds the Croatian should, first of all, be in function of forecasting future dynamics of change, and, on that basis, they could serve as guidelines when introducing any changes in the structure of pension fund portfolios.

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Functional Form of Connections between Quality of Services, Customer Satisfaction and Customer Loyalty in the Automotive Retail and Servicing Industry

Slavko Ažman
Porsche Slovenija d.o.o., Slovenia
slavko.azman@porsche.si

Boštjan Gomišček
University of Maribor, Faculty of Organizational Sciences, Slovenia
bostjan.gomiscek@fov.uni-mb.si

Abstract

Purpose - Quality of services, customer satisfaction and customer loyalty are concepts that are a crucial part of the service profit chain (Heskett et al., 2004). Although there is growing evidence of nonlinearities in connections between them, the evidence on the actual functional form is diverse. Inconsistent results of previous studies suggest that different functional forms might be typical for different industries. The aim of this study was therefore to examine the functional forms typical for the vehicle retail and repair industry and to detect possible differences in functional forms between sales and after sales.

Findings - Preliminary results suggest that a linear functional model can adequately describe the relationship between perceived quality of services and customer satisfaction for both sales and after sales. The relationship between the customer satisfaction and the customer loyalty on other hand demonstrates decreasing returns for both areas and can be therefore better described using a non-linear model.

Research Implications - The concave form of connections between the customer satisfaction and the loyalty suggests that the most effective strategy for the car dealerships for both sales and after sales would be to concentrate on improving the satisfaction of their least satisfied customers. This contradicts the recommendations based on the concept of customer delight, for which we have found no evidence.

Keywords: quality of services, customer satisfaction, customer loyalty, functional form, nonlinearity, automotive retail and repair

1 Introduction

Businesses are increasingly facing intensive global competition in a business environment that is constantly changing (Sivadas in Baker-Prewitt, 2000). This is especially true for the automotive industry (Autopolis, 2000; OICA, 2014). On top of that European automotive dealerships are facing declining new car sales (ACEA, 2014) and further liberalization of European after sales market (European Commission, 2010). In such an environment, only companies that know their customers and that constantly adopt to their needs, requirements

and expectations can be successful on the long run (Carpinetti et al., 2003). The importance of customer orientation and customer focus concepts like quality of services, customer satisfaction and customer loyalty for companies is well-documented (Duffy, 1998; Singh & Sirdeshmukh, 2000; Venkateswaran, 2003; Seth et al., 2005).

On the theoretical level the influence of customer oriented metrics such as perceived quality of services and customer satisfaction on customer loyalty and company profits is explained by the service profit chain (Haskett et al., 1994). It assumes that higher quality of services leads to higher customer satisfaction and this in turn leads to higher company profits through increased customer loyalty. Traditionally these links were considered to be linear (Cronin et al., 2000), but there is growing evidence that this might not be correct (Mittal and Kamakura, 2001, Streukens and Ruyter, 2004; Dong et al., 2011). Previous research has revealed all the theoretically possible forms of fuctional connections between the elements of the service profit chain (Ngobo, 1999; Mittal and Kamakura, 2001; Homburg et al., 2005; Dong et al., 2011). It appears that there is no universal form of functional connections between the individual elements of the service profit chain that can be found in every setting and in every industry. Therefore it was the aim of our study to examine the functional forms of these connections for the automobile industry. In particular we tried to detect any differences in functional form between sales and after sales.

2 Methodology

2.1 Data collection and sample

For the purpose of this study the results of a regular assessment of customer satisfaction with sales and after sales services in the authorized retail and repair network of four European automobile brands in Slovenia were used. The survey is regularly being conducted using computer-assisted telephone interviews (CATI). It annually involves more than 2.000 respondents for the sales services and more than 6.000 respondents for the after sales services. The questionnaire includes items on quality perception, customer satisfaction and loyalty intentions for both sales and after sales using a 5-point scale. In our study, we included the data for several years, so the total number of respondents for sales was 11.470 and for after sales the total number of respondents was 34.4421. The structure of sample regarding age, sex, regional aspects and characteristics of cars owned corresponds to the actual structure of sales and after sales customers of the dealership network of included car brands in Slovenia.

2.2 Hypothesis

Previous research has suggested that the functional links between elements of the service profit chain exist, but they are not necessarily linear (Anderson and Sullivan, 1993; Mittal et al., 1998, Anderson and Mittal, 2000; Matzler et al., 2003; Chueng and Lee, 2009; Finn, 2011). Based on that we have formed the following hypotheses:

H1a: The relationship between the quality of sales service and the customer satisfaction with the sales service in the automotive industry is positive and non-linear.

H1b: The relationship between the quality of after sales service and the customer satisfaction with the after sales service in the automotive industry is positive and non-linear.

H2a: The relationship between the customer satisfaction with the after sales service and the customer loyalty in sales (intended repurchase) in the automotive industry is positive and non-linear.

H2b: The relationship between the customer satisfaction with the after sales service and the customer after sales loyalty (intended revisit) in the automotive industry is positive and non-linear.

H3a: The relationship between the customer satisfaction with the sales service and the customer loyalty in after sales (revisit) in the automotive industry is positive and non-linear.

H3b: The relationship between the customer satisfaction with the after sales service and the customer loyalty in sales (intended repurchase) in the automotive industry is positive and non-linear.

The hypothesized links between the constructs in question are shown in Figure 1.

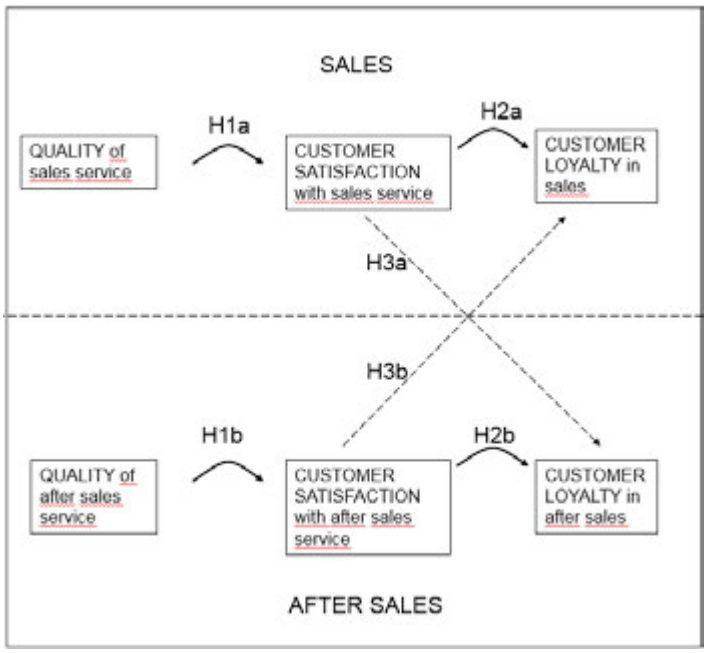

Figure 1: Hypothesized links between quality of services, customer satisfaction and customer loyalty for the automotive industry

2.3 Methods

In order to verify the proposed hypotheses, we first conducted a principle components analysis of quality items for both sales and after sales to obtain a single factor, representing quality of services. The factor values were transformed to range from 1 to 5.

Hypotheses H1a and H1b, that relate to the relationship between the service quality, customer satisfaction and customer loyalty, as well as Hypotheses H2a, H2b, H3a and H3b that relate to the relationship between customer satisfaction and customer loyalty ware tested using simple

linear regression and 6 different non-linear regression models. The non-linear regression models include quadratic, cubic, compound, S-shaped, growth, and exponential model.

Subsequently we determined the most appropriate regression model by comparing the proportion of explained variance and checked the forms of functional connections of the model with the highest explanatory by analysing its graphic representation.

2.4 Limitations of the research methods

There are several limitations of our study, main limitation of the method being the geographical limitation to Slovenia. Unfortunately, due to the policies of manufacturers, it was not possible to include the data from other European countries.

Another limitation is the fact that the study involved only authorized dealerships of specific car brands. Nevertheless, the car brands in question represent more than one fifth of the total number of vehicles registered in Slovenia (Ministry of the Interior, 2015) and almost a quarter of all new vehicles sold in European Union (ACEA, 2014). The market share of these car brands in Slovenia is with over 30% even higher (Ministry of the Interior, 2015). Another factor worth mentioning is the fact that the brands in question are very diverse, covering the entire price range and ranging from cars for the mass market to more exclusive cars.

3 Results

3.1 Results of examining the relationship between the perceived service quality and the customer satisfaction

Hypothesis H1a, which states that "the relationship between the quality of sales service and the customer satisfaction with the sales service in the automotive industry is positive and non-linear" and hypothesis H1b, which states that "the relationship between the quality of after sales service and the customer satisfaction with the after sales service in the automotive industry is positive and non-linear" were both tested with the help of the curvefit procedure in the software package SPSS.

In all models, the quality of services was defined as an independent variable and the customer satisfaction as the dependent variable. All models were statistically significant at the level <0.001. The results are shown in Table 1.

Table 1: Results of testing the hypotheses H1a and H1b

Hypotheses	H1a	H1b
Link	Quality sales - Satisfaction sales	Quality after sales - Satisfaction after sales
R^2 linear model	0.373	0.441
Best non-linear model	cubic	cubic
R^2 best non-linear model	0.378	0.452
Difference in R^2	0.005	0.011
Difference in R^2 in %	1.2%	2.4 %

Regarding the connection between the quality of services and the customer satisfaction for the area of sales the linear model can explain 37.3% of variation in the data. In terms of R^2 the cubic model that can explain 37.8% of the variance outperforms the linear model, but only

slightly. For the area of after sales these connections are somewhat stronger. Linear model shows a R^2 of 0.441. Using a non-linear model it is possible to slightly increase the R^2 to 0.452. A graphical presentation of the functional connections between the quality of sales services and the customer satisfaction with sales services (Figure 2) confirms a positive relationship. The function with the highest proportion of explained variance indicates a concave shape of connection.

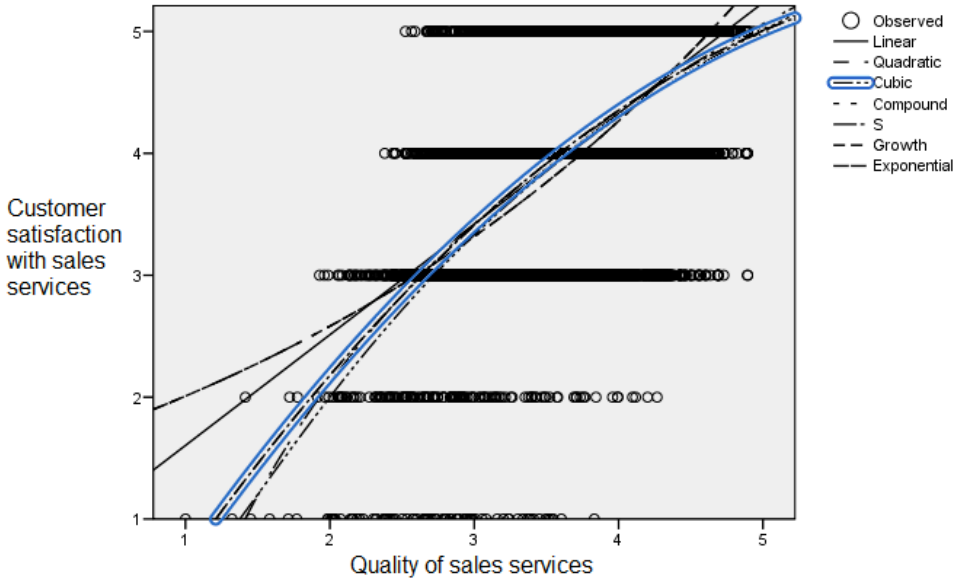

Figure 2: Graph of the functional link between the quality of sales services and customer satisfaction with sales services

The graphical presentation of the functional connections between the quality of after sales services and the customer satisfaction with the after sales services (Figure 3) confirms a positive relationship as well. The function with the highest proportion of explained variance, in this case the cubic function, indicates a concave shape of connection.

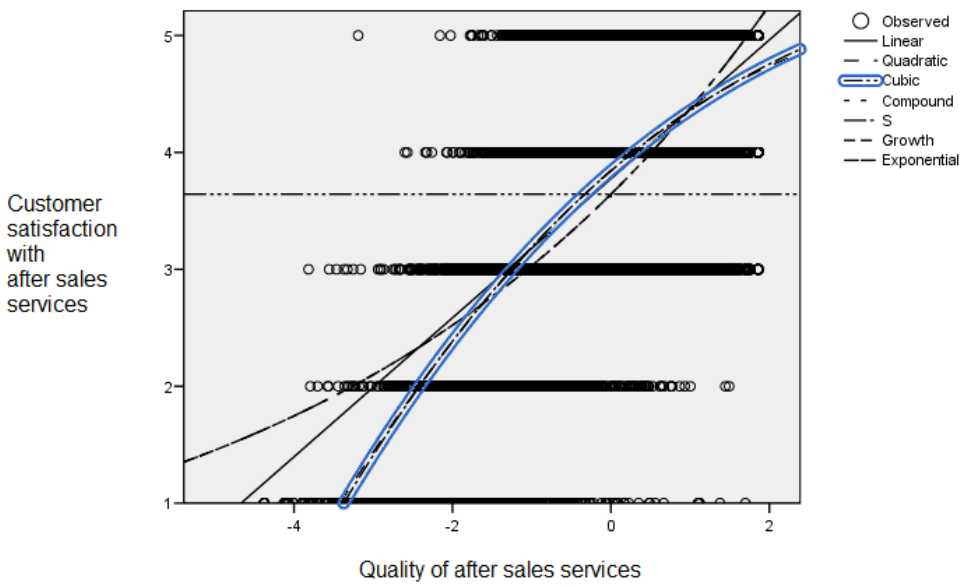

Figure 3: Graph of the functional link between the quality of after sales services and customer satisfaction with after sales services

Based on the results both hypotheses regarding the relationship between the quality of services and the customer satisfaction could be accepted.

3.2 Results of examining the relationship between customer satisfaction and loyalty

Hypothesis H2a, which states that "the relationship between the customer satisfaction with the after sales service and the customer loyalty in sales (intended repurchase) in the automotive industry is positive and non-linear" and hypothesis H2b, which states that "the relationship between the customer satisfaction with the after sales service and the customer after sales loyalty (intended revisit) in the automotive industry is positive and non-linear" were both tested with the help of the curvefit procedure in the software package SPSS. The customer satisfaction was defined as an independent variable and the repurchase intention / revisit intention as the dependent variable. All models were statistically significant at the level <0.001. The results are shown in Table 2.

Table 2: Results of testing the hypotheses H2a and H2b

Hypotheses	**H2a**	**H2b**
Link	Satisfaction sales - Loyalty sales	Satisfaction after sales - Loyalty after sales
R^2 linear model	0.197	0.257
Best non-linear model	S-shaped	S-shaped
R^2 best non-linear model	0.274	0.378
Difference in R^2	0.077	0.121
Difference in R^2 in %	39.2%	47.0%

The relationship between customer satisfaction and loyalty as measured by repurchase intent is weaker than the same relationship for after sales. R^2 of the linear model for the area sales was 0.197 compared to 0.257 for the area of after sales. In both cases, it was possible to

significantly increase the explanatory power by using non-linear models. The non-linear S-shaped model could explain 27.4% of variance for sales and 37.8% of variance for after sales.

Graphical representation of both links reveals a positive relationship (Figure 4 and Figure 5).

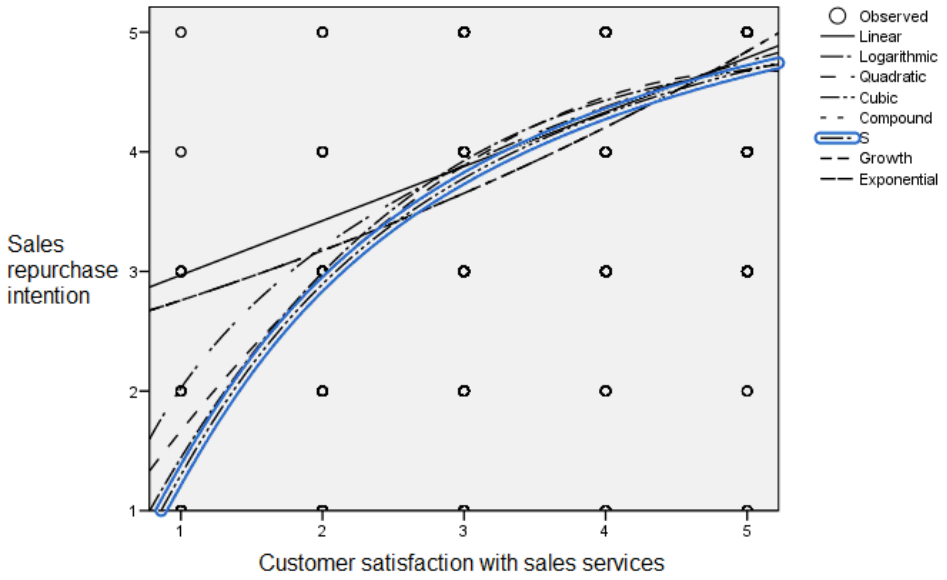

Figure 4: Graph of the functional link between the customer satisfaction with sales services and the loyalty in sales (repurchase intentions)

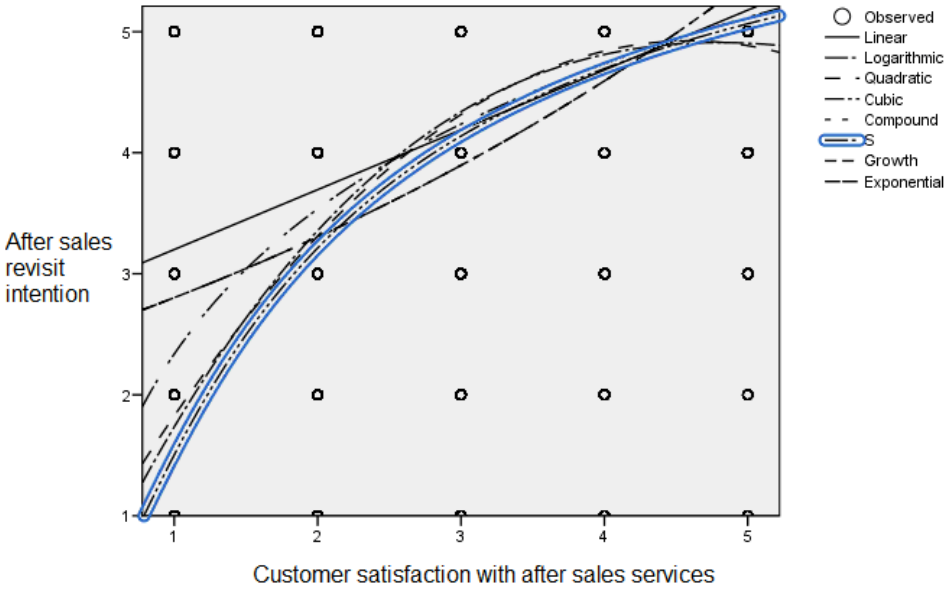

Figure 5: Graph of the functional link between the customer satisfaction with after ales services and the loyalty in after sales (revisit intentions)

The functions with the higher proportion of explained variance (in both cases S-shaped function) reveal decreasing returns, typical for concave shape of relationship.

The result enabled us to accept both hypotheses regarding the relationship between the customer satisfaction and the loyalty within the area of sales and aftersales.

3.3 Results of examining the cross-sectional relationship between customer satisfaction and loyalty

Finally, we have used the curvefit procedure in the software package SPSS to assess the cross-sectional influences of customer satisfaction on intended loyalty.

In order to check the hypothesis H3a, which states that "the relationship between the customer satisfaction with the sales service and the customer loyalty in after sales (revisit) in the automotive industry is positive and non-linear" we have first defined customer satisfaction with sales services as independent variable and after sales revisit intention as dependent variable. The results are shown in Table 3.

Table 3: Results of testing the hypotheses H3a and H3b

Hypotheses	**H3a**	**H3b**
Link	Satisfaction sales - Loyalty after sales	Satisfaction after sales - Loyalty sales
R^2 linear model	0.045	0.102
Best non-linear model	cubic	S-shaped
R^2 best non-linear model	0.072	0.122
Difference in R^2	0.027	0.020
Difference in R^2 in %	58.7%	19.2%

Although all models were statistically significant at the level <0.001, the explanatory power of the models was relatively modest. The R^2 of the linear model was 0.045, but could be increased to 0.072 by using the non-linear cubic model.

The graphical representation of the link between customer satisfaction with sales services and intended loyalty in after sales (Figure 6) confirmed the positive relationship. The cubic function as the function with the highest R^2 showed concave functional form.

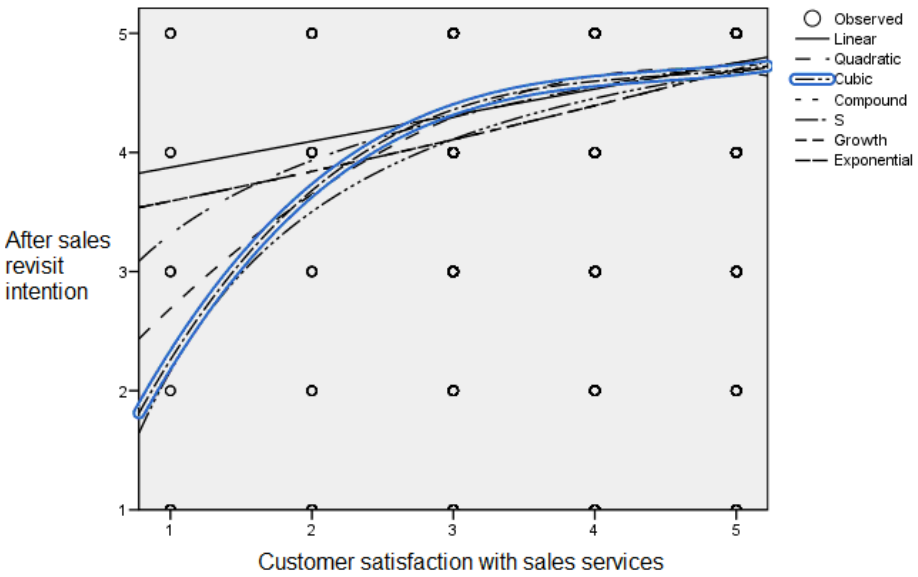

Figure 6: Graph of the functional link between the customer satisfaction with sales services and the loyalty in after sales (revisit intentions)

We have checked also the hypothesis H3b, which states that "the relationship between the customer satisfaction with the after sales service and the customer loyalty in sales (intended repurchase) in the automotive industry is positive and non-linear". The customer satisfaction with the after sales services was defined as independent variable and the intended repurchase of new car from the servicing company as the dependent variable. Also here all the models were statistically significant at the level of < 0.001.

The R^2 of the linear model was with 0.102 somewhat higher than it was in case of the link of customer satisfaction with sales on loyalty in after sales. This result could be improved by using the non-linear S-shaped model (Table 3).

The graphical representation of functional link between the customer satisfaction with after sales services and the loyalty in sales demonstrates a positive connection too (Figure 7).

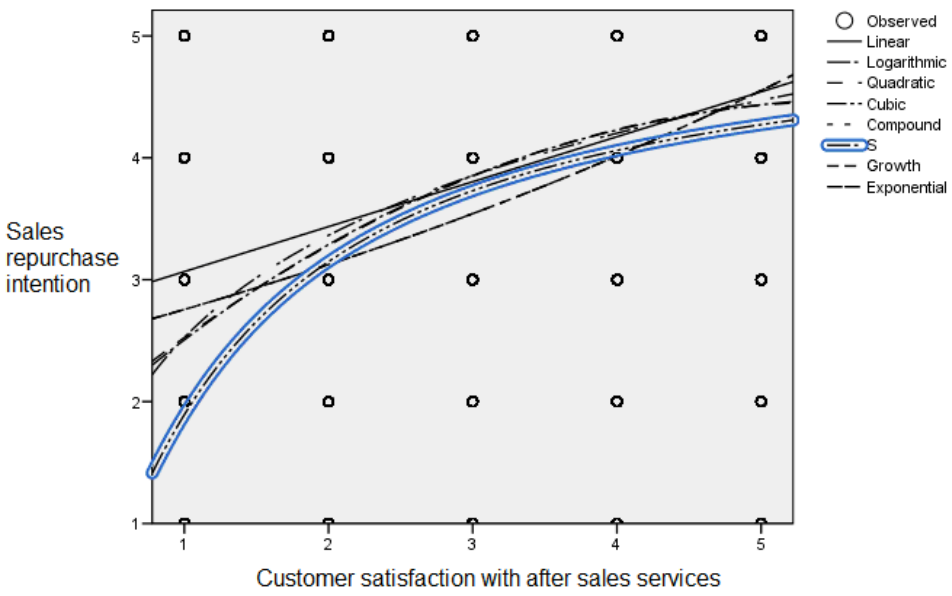

Figure 7: Graph of the functional link between the customer satisfaction with sales services and the loyalty in after sales (revisit intentions)

Both hypotheses regarding the cross-sectional influence of customer satisfaction on customer loyalty could be accepted.

4 Discussion and Conclusions

4.1 Relationship between the quality of services and the customer satisfaction

Preliminary results of our study concerning the functional link between quality of service and customer satisfaction for sales as well as for after sales revealed that this link exists, and that it is positive. In this part our findings correspond with the findings of previous research (Anderson and Mittal, 2000; Giovanis et al. 2014; Blut et al., 2015).

For the sales as well as for the after sales area the results propose concave shape of the links, suggesting diminishing influence of quality of services on customer satisfaction. However, it is necessary to point out that the differences in the proportion of explained variance between linear and nonlinear model for both areas are small. This is consistent with some previous research. For example, Mittal and co-authors (1998) found evidence of non-linearity in the relationship between individual attributes of quality on customer satisfaction, but at the level of the entire model, which included all the attributes of quality of service, the explanatory power of non-linear model did not surpass the explanatory power of the linear model. Similarly Ting and Chen (2002) found that although it is possible to detect different non-linear effects of individual quality attributes on customer satisfaction, on the level of the entire model there is little difference between the linear and the non-linear model.

Based on comparable results (almost identical R^2 of linear and non-linear model) Mittal et al. (1998) considered the non-linearity to be proven and recommended the use of nonlinear models. In contrast to them, we believe that in the case of the link between quality of services and the customer satisfaction the use of more complex nonlinear models is not justified, at least in the automotive industry. Improvements of the explanatory power of the non-linear model compared with the linear one are simply too small. Almost identical R^2 at the same time means that the linear model is appropriate to describe the link in question.

4.2 Relationship between the customer satisfaction and the customer loyalty

The preliminary results of our study on the link between the customer satisfaction and the customer loyalty confirmed the findings of previous research (Heskett et al., 1994; Streukens & Ruyter, 2004; Dong, 2011) that the link between these two constructs exists and that it is positive. Our study revealed a concave form of functional connections between customer satisfaction and customer loyalty for both sales and after sales. The concave functional form that reflects decreasing impact of customer satisfaction on customer loyalty, was predicted by the accessiability – diagnosticity theory (Skowronski in Carlston, 1989) and also by the need-gratification theory for lower order goals (Agustin & Singh, 2005).

Regarding the form of functional connection between customer satisfaction and customer loyalty our findings contradict the findings of some previous studies. For example, Jones and Sasser (1995) used the automotive industry as an extreme example of an increasing impact of customer satisfaction on customer loyalty. Their findings were that the shape of functional connection between the constructs in question is highly dependent on the intensity of the competition (Figure 2). Therefore, in the sectors with high levels of competition, such as the automotive industry, a convex shape of functional connection should be found.

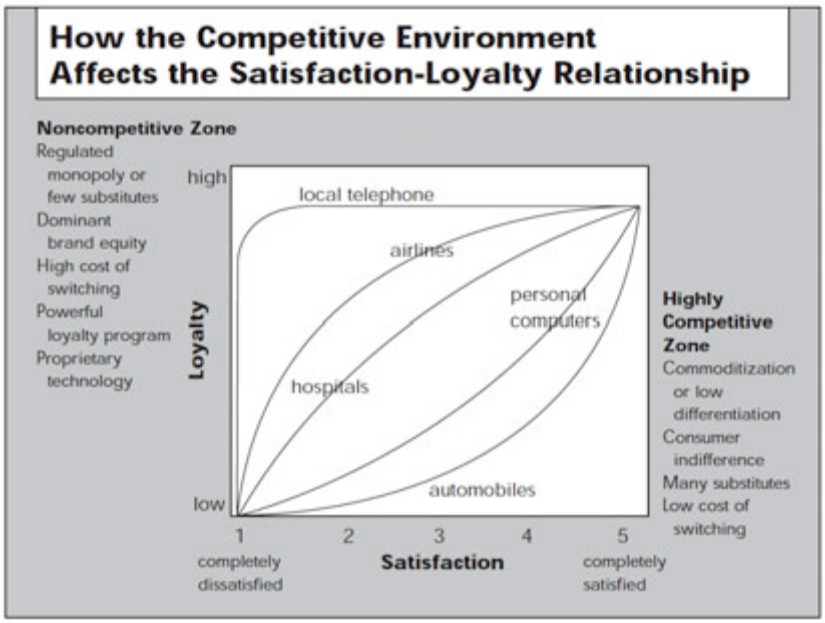

Figure 2: How the competitive environment affects the satisfaction-loyalty relationship
Source: Jones & Sasser (1995)

Indicator like number of personal cars per 1000 inhabitants clearly shows that Slovenian automotive market is without any doubt a highly developed, saturated market (ACEA, 2013). With 512 registered passenger cars per 1000 inhabitants in 2011, Slovenia exerted a higher number as the average for European Union (483), Unites States (417) or Japan (452). Given the declining numbers of new cars sold since 2008 (Ministry of Interior, 2015) there is little doubt about the intensity of competition in Slovenian automotive market, both in sales and in after sales. The European Commission also acknowledged this fact in its decision to stop monitoring the level of competition in European automotive markets (European Commission, 2011). The lack of competition therefore could not be a reason for different results of our study.

On the other hand, Mittal & Kamakura (2001) also found evidence for declining impact of customer satisfaction on repurchase intent in their study, based on a large sample of over 100.000 European new car buyers.

For concave link, which exhibits a diminishing impact of satisfaction on loyalty and was observed in our study, the most effective strategy is to focus on the least satisfied customers, as the improvement of their satisfaction would have the biggest impact on their loyalty. This contradicts a popular concept of customer delight that assumes that the only way to prevent the customers from switching to the competition is not just to satisfy them but to delight them (Oliver et al.,1997; Arnold et al., 2005; Kim & Mattila, 2013).For the automotive industry, we have found no evidence for the effectiveness of strategies trying to achieve customer delight.

4.3 Cross-sectional influences of customer satisfaction on customer loyalty

Our research showed that satisfaction with sales services does not affect only the intended loyalty in sales, but also the loyalty to the seller in after sales. It also showed that satisfaction with the after sales services does not affect only the intended re-visit in after sales, but also influences the intention to buy a new vehicle at the service center.

The cross-sectional influence of satisfaction on loyalty is much smaller than the direct one, which was to be expected. But nevertheless the results of our study show that the areas of sales and after sales are linked. This is consistent with the experience from the practice. While the newly opened dealerships can relatively soon make their targets in sales, they usually need several years until they can attract enough customers in after sales. The reason is that in the after sales they can count primarily on the customers that have bought a new car at the same dealership. Established dealerships on the other can also experience a decline of customers in the after sales after several years of poorer performance in sales.

Our research shows that there is not only an impact of performance in sales on the performance in after sales, but also the opposite is true. Through the customer satisfaction with after sales services it is possible for dealership to influence the relationships with their customers in sales. This is especially important due to long purchase cycles, typical for new vehicles (DAT, 2013), because after sales services give a dealership rare and important possibilities to interact with their new car buyers and to maintain a long term relationship with them.

Similar to the direct impact of satisfaction on loyalty within a particular area, the functional connection between satisfaction and loyalty across the sales / after sales boundary shows a concave shape. R^2 of non-linear models is only 2 to 3 percentage points higher that the R^2 of the linear model, but due to the very low level of R^2 this means a notable percentage of

increase in explanatory power. The concave shape of functional connections means that also in these cases the impact of satisfaction on loyalty is decreasing. Also from perspective of cross-sectional impact, it makes more sense to focus on preventing dissatisfaction rather than trying to further increase the existing relatively high levels of satisfaction.

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Time-Bounded Analysis of Business Processes with P-Graph Methodology

János Baumgartner
University of Pannonia, Department of Computer Science and Systems Technology, Hungary
baumgartner@dcs.uni-pannon.hu

Zoltán Süle
University of Pannonia, Department of Computer Science and Systems Technology, Hungary
sule@dcs.uni-pannon.hu

Tünde Tarczali
University of Pannonia, Department of Computer Science and Systems Technology, Hungary
tarczali@dcs.uni-pannon.hu

Abstract

Business process modeling and the optimization of business processes are one of the key factors that have an influence on the life of the companies and organizations. It is obvious that changes in the business processes or workflows have effects on the efficiency, moral and costs. According to this thought the leaders of the organizations aspire after the determination of the most effective way when the flows in the everyday life of the organizations are optimized. A defining language, Business Process Model and Notation (BPMN) was introduced to describe and design companies' processes. It represents the processes in a company properly, but does not ensure adequate tools for mathematical analysis. The P-graph methodology was introduced in the middle of the 90's to provide an approach for optimizing costs of producing systems. In our work we developed a way to transform a Business Process Diagram (BPD) into a P-graph enabling the possibilities of examining a business process algorithmically and mathematically. In this paper a case study is shown where processes of a local government are analyzed. The given BPD is automatically transformed into P-graph then cost optimal solutions are calculated taking the time constraint into account.

Keywords: Business Process Diagram (BPD), Transformation, Optimization, P-graph Methodology

1 Introduction

Design and management of business processes show up as a key factor for companies to effectively compete in today's volatile business environment. By focusing on the optimization and continuous improvement of business processes, organizations can establish a solid

competitive advantage by reducing cost, improving quality and efficiency, and enabling adaptation to changing requirements. Business Process Modeling Notation (BPMN) provides the capability of understanding the internal business procedures in a graphical notation by defining a Business Process Diagram (BPD).

Business process diagram is based on a flowcharting technique very similar to activity diagrams from Unified Modeling Language (UML). Diagram consists of sets of graphical elements. For both business users and developers, they simplify understanding business activities' flow and process. The basic four element categories are: flow objects, connecting objects, swim lanes and artifacts. These four categories enable creation of simple business process diagrams. A business process diagram represents the processes in a company properly, but does not ensure adequate tools for mathematical analysis. Therefore, we need a methodology which support the examinations of business processes algorithmically, and give mathematically based techniques for analyzing and optimizing them.

In our work a novel mathematical approach will be shown by which analysis and optimization of business processes can be supported by an own software tool where potential decision alternatives and the optimal solution can be generated automatically. The mathematical background of optimization of the processes can be handled by P-graph methodology.

2 Mathematical background

The P-graph methodology was introduced in the middle of the 90's by Friedler et al. (1992) to provide an approach for optimizing costs of producing systems. Several algorithms were developed as part of this methodology, such as MSG (Maximal Structure Generator), which gives the maximal structure of a process described by the P-graph, SSG (Solution Structure Generator) for generating all the solution structures of the graph, and ABB (Accelerated Branch-and-Bound) for identifying the optimal and near optimal processes (Friedler et al. 1992, 1993, 1995).

P-graphs were used in various applications in last years: Fan et al. (2005) applied P-graphs for reaction pathways identification, Vance et al. (2014) designed energy supply chains using P-graphs, and Bertok et al. (2013) introduced a method for calculating the reliability of supply chains based on P-graphs. A P-graph is a bipartite graph, where M is a finite set, and set O satisfies the constraint $O \subseteq \wp(M) \times \wp(M)$ where $\wp(.)$ is the power set, and $\times$ is the cartesian product. Pair (M,O) is defined to be a process graph or P-graph; the set of vertices of this graph is $M \cup O$, and the set or arcs is a where

$$a = \{(X,Y) | Y = (\alpha,\beta) \in O \text{ and } X \in \alpha\} \cup \{(Y,X) | Y = (\alpha,\beta) \in O \text{ and } X \in \beta\}.$$

The sets M and O represents the materials and operating units. Every operating unit consume materials on their input and produces ones on their output. Special materials are also defined such as raw materials and products. The goal is to produce products from available raw materials using operating units.

Several parameters must be taken into account when business processes are examined and optimized. The goodness of a business process is not only defined by its low costs but also by time-constraints on activities. So the time-constraint parameters must be taken into consideration in the model in addition to cost when the optimal structures are identified. The execution time is a dominant property of activities in business processes which depends on the quantity of the job has to be done. These parameters are assigned to every operating unit as well, resulting an extended mathematical model. For handling this complex model, a

computer software and solver was developed based on P-graph algorithms, which gives the cost optimal solution(s) considering time-constraints of operating units.

For analyzing business processes the rules of BPD - P-graph transformation have been defined. The P-graph equivalent of an event from BPD is a material type node and an operating unit type node which consumes it. If the event is a starting point of the business process than the material type node will be a raw material. On other hand if the event is final point of the process, i.e. the end event, it can be transformed to P-graph with an additional product type node. Transformation of the activities defined by BPD is similar to the events, i.e. it is equivalent with an operating unit and a consumed material. BPD uses gateways for presenting decisions. There are two basic gateways defined in BPD which are the AND and the OR gateways. BPD to P-graph transformation of these two basic gateways was introduced in Tarczali et al 2013 and 2014.

The AND operation means that all of the inputs are required for the processing and for the output generation. The P-graph equivalent of this operation is an operating unit with the same number of the input and output edges as the AND gateway has. The OR gateway means that at least one of the input is required for the processing and for the output generation. The P-graph equivalent of the OR gateway is a material type node with the same number of the input and output edges as the OR gateway has.

3 Case study

In this section an illustrative example will be shown for optimizing a business process starting from a BPD. This study describes the handling of complaints at a local government office, where three different types of application form can be submitted by citizens. To solve these tasks, four employees can be allocated to the complaints. The goal is to minimize the costs as well as to give the corresponding assign of employees to the jobs. It is also needed to decide whether it satisfies a given deadline or not. Our example can be described by the following business process diagrams where Figure 1 shows the life cycle of one document which starts from receiving it from a citizen.

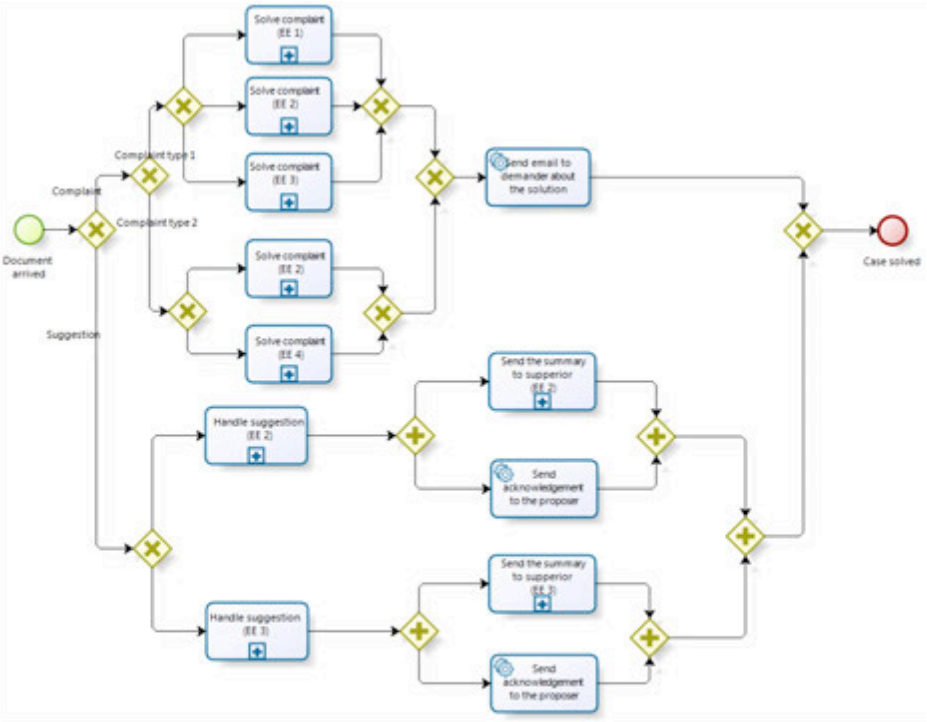

Figure 1: BPD of processing one document

Furthermore, Figure 2 represents the whole process at the office handling more pieces and types of documents.

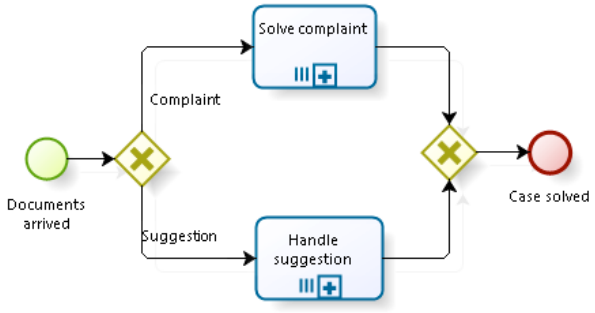

Figure 2: BPD of processing many documents

The result of the BPD-P-graph transformation can be seen on Figure 3. The three types of documents and four employees are represented as raw materials, while the solved requests are given as products in the P-graph. Analyzing this mapping structurally, 63 different scenarios can be identified, and the optimal one comes from these solution structures.

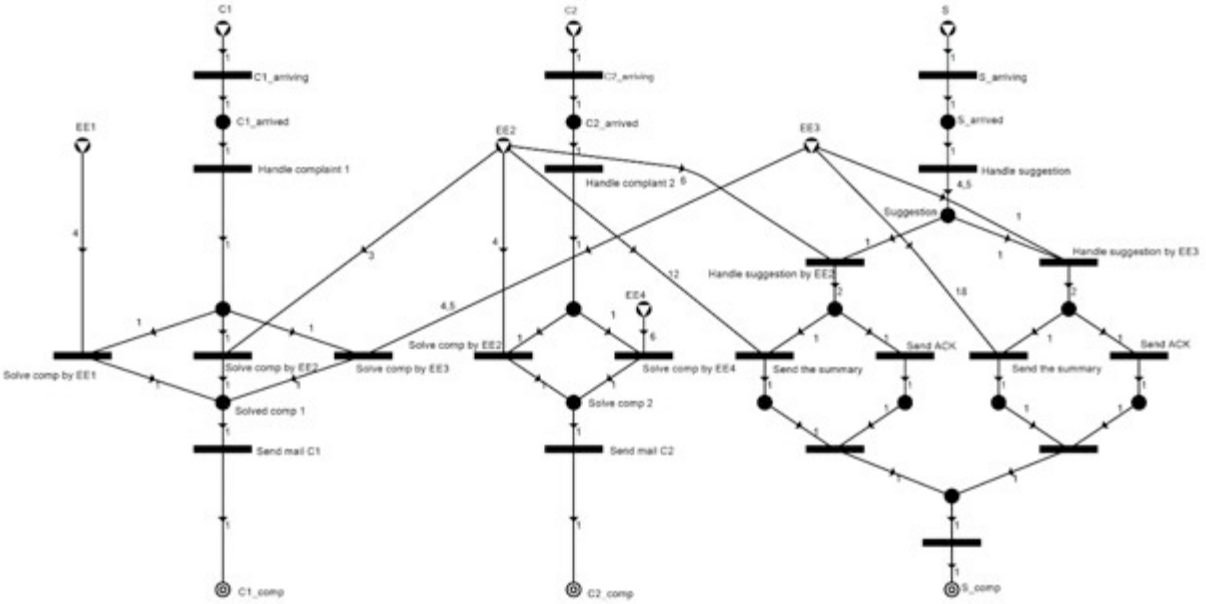

Figure 3: The P-graph representation of the given BPD

The parameters of the tasks are shown in the following Table 1 and 2, which represent the possible employee-task assigning, the cost, and the time parameters of the tasks depending on the employees.

Table 1: Cost parameters of each task solved by employees

Employees and total cost of tasks	Solve Complaint 1 (cost)	Solve Complaint 2 (cost)	Handle suggestion (cost)	Send the summary (cost)
Employee 1	€4	-	-	-
Employee 2	€3	€4	€6	€12
Employee 3	€4,5	-	€4,5	€18
Employee 4	-	€6	-	-

In our illustrative example that situation was examined when numbers of complaint 1, 2 and suggestion were 20, 29, and 7. First of all, the cost optimal solution was determined, when time limit was ignored in the problem. Each employee works full-time at the council, which means 8 hours per days and employees. The structure of the optimal solution can be seen in Figure 4, where the optimal cost is €366,2, meanwhile employee 1 spends 62,5% of his/her total time, employee 2 and 3 work in full-time, as well as the employee 4 spends 48,12% of his/her available working time for solving the complaints.

Table 2: Time parameters of each task solved by employees

Employees and execution time of tasks	Solve Complaint 1 (minutes)	Solve Complaint 2 (minutes)	Handle suggestion (minutes)	Send the summary (minutes)
Employee 1	15 min	-	-	-
Employee 2	15 min	20 min	30 min	60 min
Employee 3	15 min	-	15 min	60 min
Employee 4	-	30 min	-	-

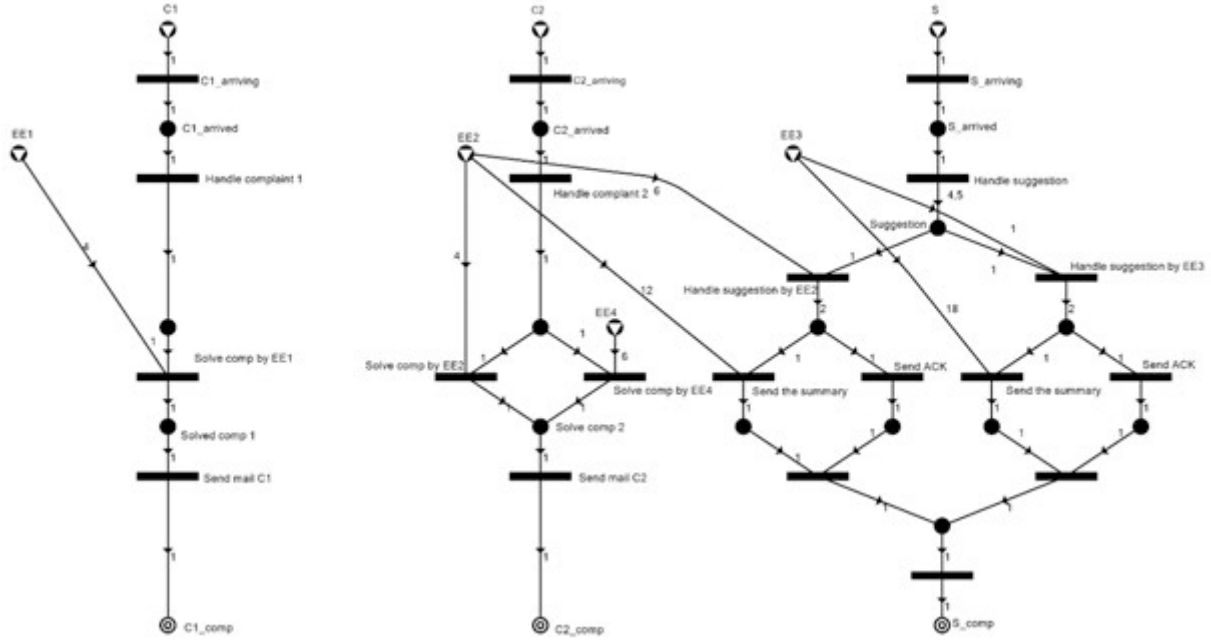

Figure 4: The structure of the optimal solution (cost = €366,2, time = 480 min)

In that case if the employee 2's working time is reduced to 70% due to his/her other issues, the optimal cost of execution will increase by €14,4, when employee 1 expends 62,5%, employee 2 and employee 3 work 70%, and employee 4 uses 93% of his/her working time for solving the received complaints. The structure of the solution structure remained the same.

If a time bound is limited to 7 hours, i.e. the tasks have to be done in 7 hours, the cost increases to €369,8, and the task allocation will also be changed. Employee 1 uses 62,5%, employee 2 100%, while the third and fourth employee spend 87,5% and 70,6% of his/her available working time for solving the assigned problems. In that case the complaints are solved in 7 hours.

At time minimization, our goal is to complete the tasks as soon as possible. We found that at least 391 minutes are needed for handling the tasks under cost €371,53. As it can be expected, the lower we want to keep the costs, the more time is needed to complete the process. Cost constraints can be added to the model as well, which can result the re-arranged of task-

employee allocation. Adding a €370 cost upper bound to the problem, the needed time increases to 416,7 minutes.

The mathematical model and the P-graph can be extended for handling exclusive operating units when some of them must not appear in the structure at the same time. For handling this requirement temporary operating units and materials will be added to the graph (see Figure 5) and special parameter values are assigned to these new nodes. Using this extension guarantees that each task will be done by exactly one employee. The *Ex1*, *Ex2*, and *Ex3* nodes are such temporary raw materials, which ensure the exclusive-OR logical connections among the tasks. The maximum available amount of any temporary raw material node is exactly one unit. In the last part of the case study, this special case is considered and the optimization is done subject to this constraint.

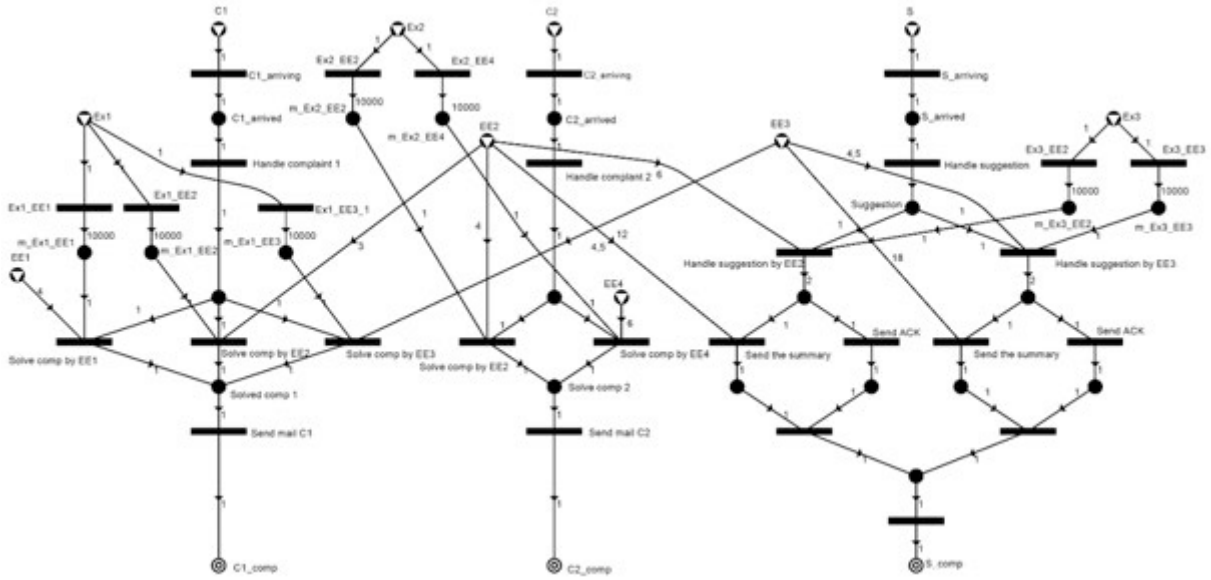

Figure 5: The extended P-graph for handling exclusive operating units

If the numbers of complaint 1, 2 and suggestion are 15, 12, and 4, as well as one task is executed by exactly one employee, six feasible structures are found for solving this special problem. The P-graph methodology is a capable tool to generate all the feasible structures. Table 3 shows the parameters of the feasible structures and the numbers of documents which are solved by Employee 1, 2, or 3, while Figure 6 represents the structure of the optimal solution.

Table 3: The six-best solution of the problem

#	Number of complaint 1 to be solved by			Number of complaint 2 to be solved by		Number of suggestion to be solved by		Total cost	Total time
	EE1	EE2	EE3	EE2	EE4	EE2	EE3		
1	0	15	0	12	0	0	4	€183	465 min
2	15	0	0	12	0	0	4	€198	300 min
3	15	0	0	0	12	4	0	€204	360 min
4	0	15	0	0	12	0	4	€207	360 min
5	0	0	15	0	12	4	0	€211,5	360 min
6	15	0	0	0	12	0	4	€222	360 min

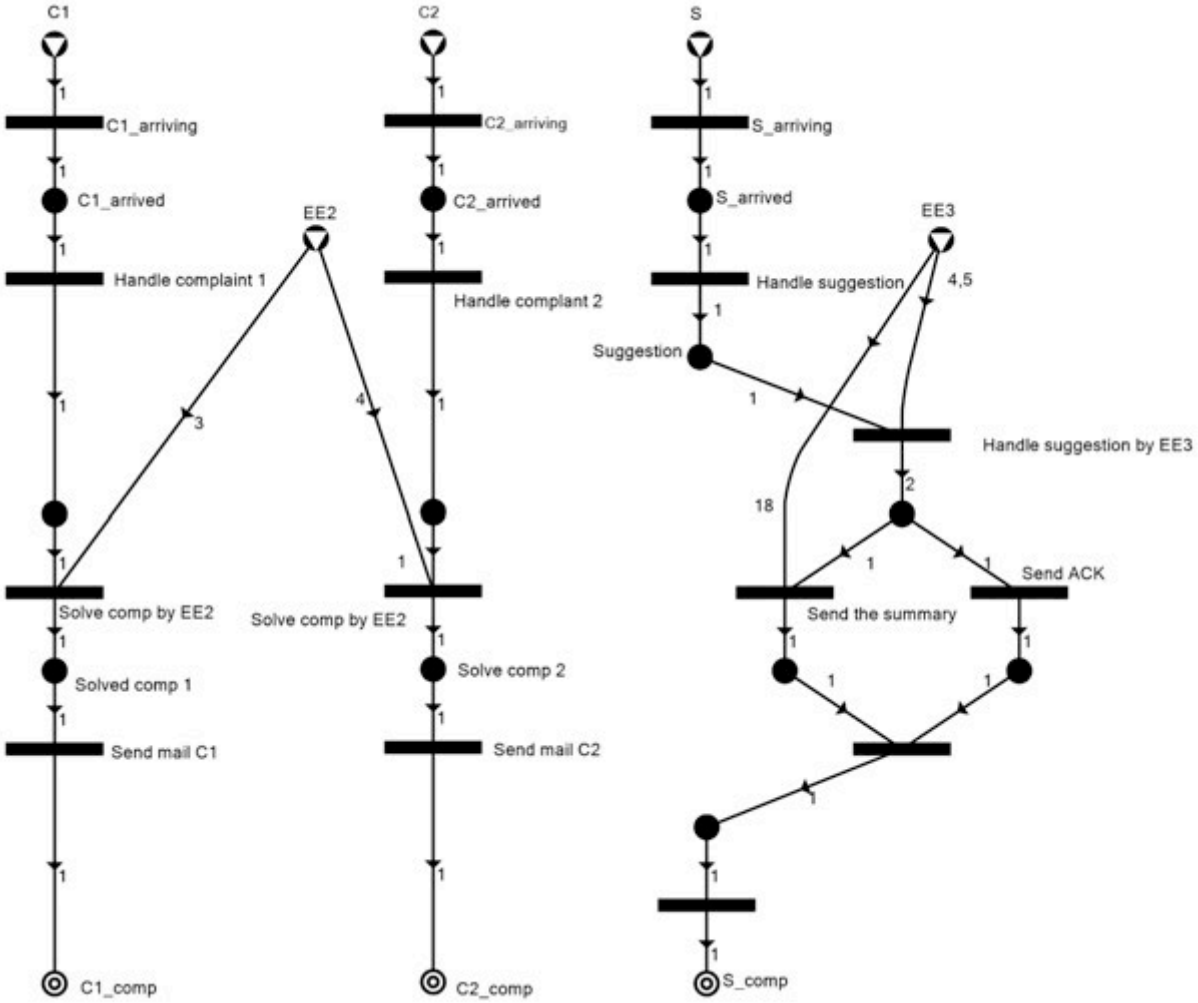

Figure 6: Optimal solution of the problem

The results were calculated by the PNS Studio software designed to solve optimization tasks Process Network Synthesis problem. Process synthesis is the act of conceiving or determining

the optimal structure of a process system of concern as well as the optimal types, configurations, and capacities of the functional units performing various operations within the system. For more details see www.p-graph.com.

4 Summary

Managers and decision makers often use BPDs for describing several business processes. It is required to make these processes more efficient and find the optimal one from numerous different scenarios. There is no effective formal approach for mathematically and algorithmically analysis of BPDs, therefore a novel technique was introduced in this paper for analyzing and optimizing business processes taking into consideration cost and time parameters. The P-graph methodology was applied, and transformation rules from BPD to P-graph were introduced to support the examinations of scenarios, where the business processes are handled as a process network synthesis problem. Illustrating our methodology a case study was shown where processes of a local government are analyzed and the cost optimal solutions were given taking into account time bounds. Contrary to conventional mathematical programing methods, the P-graph approach provides not only the optimal solution but the *n*-best solutions as well. A wide spectrum of potential solution structures are given by the algorithm, and the best decision can be selected by decision-makers. The developed mathematical method supports the graphical representation as well as the multi-objective optimization of business processes giving the organizations the opportunity for increasing theirs competitiveness.

Acknowledgement

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Macroeconomic Determinants of the Non-Performing Placements and Off-Balance Sheet Liabilities of Croatian Banks[1]

Manuel Benazić
Juraj Dobrila University of Pula
Faculty of Economics and Tourism "Dr. Mijo Mirković", Croatia
manuel.benazic@unipu.hr

Dajana Radin
Juraj Dobrila University of Pula
Faculty of Economics and Tourism "Dr. Mijo Mirković", Croatia
dradin@unipu.hr

Abstract

The non-performing placements and off-balance sheet liabilities are often considered key factors that lead to banking crises. Economic and financial crises increase the level of the non-performing placements and off-balance sheet liabilities which can cause significant losses for banks. Effective management and regulatory institutions such central banks should be able to recognize and quantify these effects. Therefore, the aim of this study is to determine the impact of main macroeconomic variables on the non-performing placements and off-balance sheet liabilities of Croatian banks. For this purpose the bounds testing (ARDL) approach for cointegration is applied. The results indicate the existence of stable cointegration relationship between the variables i.e. in the long-run, an increase in real GDP reduces the level of the non-performing placements and off-balance sheet liabilities of Croatian banks wherein an increase in prices, unemployment, interest rate and the depreciation of the Croatian kuna exchange rate increases their level. On the other hand, in the short-run the results are rather mixed.

Keywords: non-performing placements and off-balance sheet liabilities, macroeconomic determinants, Croatian banks, cointegration, ARDL approach

1 Introduction and literature review

The non-performing loans (NPLs) are often considered as a key factor in banking and financial crises in both developing and developed countries. Economic and financial crises

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increase the level of the NPLs affecting the liquidity and profitability of banks and thereby the financial stability of the banking systems which in turn can cause significant losses for banks. Namely, an increase in the NPLs leads to an increase in value adjustment costs and provisions generating lower profits and profitability bank indicators. The loan's portfolio quality will deteriorate as a result of internal factors (bank-specific), as well as a result of problems that could be generated by the economy developments (macroeconomic factors). Although banks have developed sophisticated techniques for quantifying *ex ante* credit risk by focusing on the borrower's idiosyncratic features, the *ex post* credit risk as reflected in the number of the NPLs seems to be primarily driven by macroeconomic developments (Louzis, Vouldis and Metaxas, 2010). Therefore, it is common that during difficult economical conditions the level of the NPLs increases. As summarized in Shingjergji and Shingjergji (2013) the main reasons of the NPLs growth are as follows: a) general reasons: the economical crises consequences; the currency depreciation; the ownership problems; the high costs of re – financing, b) businesses reasons: the slowdown in the construction sector; the unstudied expansion of businesses; the general lack of liquidity in the market; the liquidity problems that go from one business to another as a chain; the exports' contraction; the sales decline as a result of the purchasing power reduction; the loans overload, c) individuals reasons: the remittance decline; the interruption of the employment relationship, especially in the private sector; the reduction of personal and familiar incomes; the unreliable incomes certificates; the high rate of unemployment; the slow pace of wage growth. Despite mentioned reasons, bank-specific characteristics such as the quality of management, policy choices, size and market power on problem loans also affect the number of the NPLs (Louzis, Vouldis and Metaxas, 2010). However, the analysis in this paper is primarily focused on the macroeconomic determinants and therefore bank-specific characteristics will not be discussed in details[2].

Another important issue stressed by Louzis, Vouldis and Metaxas (2010) is that macroeconomic and bank-specific variables can have a differential impact on the NPLs depending on the type of loan. This could be attributed to institutional settings creating different incentive structures for each type of loan with regards to the costs of bankruptcy. Moreover, differences in the sensitivity of various types of the NPLs to macroeconomic developments may be linked to differential effects of the business cycle on agents' cash flows and collateralized assets' values.

According to the Croatian National Bank (CNB) Decision on the classification of placements and off-balance sheet liabilities of credit institutions[3] placements include all financial assets in a form of granted loans, debt instruments and other receivables, classified by a credit institution into categories of financial instruments, in accordance with its business policies, which are designated as "loans and receivables" and "held-to maturity investments" while off-balance sheet liabilities mean traditional off-balance sheet risky items, i.e. liabilities (which do not include the contractual value of derivative instruments), the settling of which requires or might require an outflow of credit institution's cash, on the basis of which, due to uncollectibility of the future outflow of credit institution's funds, the credit institution is exposed to credit risk (issued guarantees, opened uncovered letters of credit, letters of

[2] For details regarding the bank-specific determinants please see Louzis, Vouldis and Metaxas (2010), Klein (2013), Messai and Jouini (2013), Shingjergji (2013), Shingjergji and Shingjergji (2013), Makri, Tsagkanos and Bellas (2014), etc.

[3] Credit institution may be established as a bank, savings banks, housing savings bank or an electronic money institution (Croatian National Bank, 2008) whereby banks are the largest and most important of all institutions (Croatian National Bank, 2014).

guarantee, commitments under credit contracts, etc.) (Croatian National Bank, 2013). Credit institutions, which include banks, shall classify placements into the appropriate risk categories on the basis of the debtor's creditworthiness criteria, debtor's timeliness in meeting their obligations towards a credit institution and other creditors, and quality of instruments of collateral for credit institution's receivable. Depending on the possibilities of collection, i.e. on estimated future cash flows, all placements are classified into three broad categories (regardless of whether exposures are individually significant or they belong to a portfolio of small loans). First category includes placements for which no objective evidence of impairment has been identified on an individual basis (risk category A). Second category includes placements for which objective evidence of partial impairment has been identified, i.e. partly recoverable placements (risk category B, consisting of risk sub-categories B-1, B-2 and B-3) while third category includes placements for which objective evidence of full impairment has been identified, i.e. fully irrecoverable placements (risk category C). With respect to the assessed possibility of recovering the expected outflow of a credit institution for the purpose of settling off-balance sheet liabilities, these liabilities are classified into three broader categories. First category includes off-balance sheet liabilities for which no outflow of credit institution's funds is expected, or if the outflow occurs, it is expected to be fully recovered (risk category A). Second category includes off-balance sheet liabilities for which outflow of credit institution's funds is expected that will not be fully recoverable (risk category B-1, B-2 and B-3) while third category includes off-balance sheet liabilities for which outflow of credit institution's funds is expected that will be fully irrecoverable (risk category C). It should be emphasized that loans have the highest share in the structure of placements and off-balance sheet liabilities of Croatian banks. For example, on 31 December 2013 the portfolio of loans and receivables accounted for 85,6% of total placements and off-balance sheet liabilities (of which loans 68,6%) while off-balance sheet liabilities accounted for 12,2% (Croatian National Bank, 2014).

During the last two decades Croatian banking system has gone through a tumultuous period. Rapid privatization, deregulation and lack of appropriate regulation together with two banking crisis in the first decade generated significant losses for banks and bank failures. The second decade was mainly characterized by opening of the financial and banking market with the arrival of foreign capital and banks which led to the enhancement of financial intermediation, strong credit growth and consequently to the higher level of the non-performing placements and off-balance sheet liabilities caused by the recent global recession. Throughout the entire period, the CNB has implemented a number of prudential and monetary policy measures to reduce the level of the non-performing placements and off-balance sheet liabilities (Gardó (2008), Galac (2011)).

There is a vast growing literature analyzing the effects of macroeconomic variables on the NPLs. However, the empirical literature related to determinants of the NPLs (i.e. the non-performing placements and off-balance sheet liabilities) in Croatia is very scarce. Therefore, the following overview of empirical papers in European countries will help us to understand the overall effects of the impact of main macroeconomic variables on the NPLs.

Croatian National Bank (2008) analyzed the impact of the macroeconomic environment on credit risk in Croatia using quarterly data in the period from 1997 to 2007 and the ordinary least squares (OLS) model. Obtained regression coefficients showed that annual rate of change in GDP and the annual rate of change in exchange rate are statistically significant and have the expected signs, i.e. the depreciation of the domestic currency and the slowdown in economic growth are positively correlated with the annual rate of change in the NPLs while

interest rate is proved to be statistically insignificant as well as inflation and the level of indebtedness.

Louzis, Vouldis and Metaxas (2010) examined the determinants of the NPLs in the Greek banking sector, separately for each type of loan (consumer, business and mortgage loans) using quarterly data in the period from March 2003 to September 2009 and dynamic panel data methods. The results indicate that the NPLs in the Greek banking system can be explained mainly by macro-fundamentals (GDP, unemployment, interest rates) and management quality. The real growth is proved to be negatively related to changes in the NPLs ratio, while the unemployment rate and the real lending rates have a positive impact.

Erjavec, Cota and Jakšić (2012) employed the Uhlig's sign restriction approach to stress-testing of the Croatian banking system using quarterly data in the period from June 2000 to June 2010. The analysis is based on a standard monetary VAR (vector autoregressive) model comprising real economic activity, inflation and short-term interest rates augmented by the ratio of the NPLs or return on average equity. The results suggest a strong sensitivity of the Croatian banking sector to macroeconomic shocks. More precisely, estimated impulse response functions suggest that all shocks lead to an increase of credit risk (measured by changes in the rate of the NPLs) and a decrease of Croatian banking sector profitability (return on average equity).

Olaya Bonilla (2012) analyzed the main macroeconomic determinants of the NPLs in Italy and Spain using monthly data in the period from January 2004 to March 2012 and the ordinary least squares (OLS) model. Obtained results indicate that in both Spain and Italy, the macroeconomic variables are strong determinants of the NPLs. However, of the five explanatory variables used, i.e. credit growth, wage, inflation, unemployment and GDP, only unemployment, wage and GDP turned out to be statistically significant. Unemployment is found to be positively correlated with the NPLs in both countries while wage is neutral. Regarding GDP results are mixed, i.e. the GDP is found to be negatively correlated with the NPLs in Spain and positively correlated in Italy.

Moinescu (2012) analyzed the determinants of the NPLs in Central and Eastern European Countries using annual data in the period from 2003 to 2011, conditional risk model and dynamic panel regressions with fixed effects. Obtained results suggest that the NPLs ratio is significantly adjusting to economic developments while inflation, exchange rate changes and three month money market interest rate exercise positive effects.

Beck, Jakubik and Piloiu (2013) analyzed the macroeconomic determinants of the NPLs across 75 countries using annual data in the period from 2000 to 2010 and panel estimation techniques. According to panel estimates, real GDP growth, share prices, the exchange rate, and the lending interest rate significantly affect the NPLs ratios. Regarding the exchange rates, the direction of the effect depends on the extent of foreign exchange lending to unhedged borrowers which is particularly high in countries with pegged or managed exchange rates while regarding share prices, the impact is found to be larger in countries which have a large stock market relative to GDP.

Bošnjak, Novak and Šverko (2013) analyzed the macroeconomic shocks effect on the NPLs level in Croatia as a small open economy in the period from 1997 to 2012 using the VAR (vector autoregressive) model. They found the negative correlation between the GDP growth level and the NPLs ratio.

Klein (2013) investigated the NPLs in Central, Eastern and South-Eastern Europe (CESEE) using annual data in the period from 1998 to 2011 and a panel VAR (vector autoregression)

analysis. The results indicate that the level of the NPLs can be attributed to both macroeconomic conditions and banks' specific factors, although the latter set of factors is found to have a relatively low explanatory power. Obtained results suggest that higher unemployment rate, exchange rate depreciation (against the euro) and higher inflation contribute to higher NPLs while higher Euro area's GDP growth results in lower NPLs. Higher global risk aversion (VIX) was also found to increase the NPLs. The impact of bank-specific factors suggest that equity-to-asset ratio and return on equity (ROE) are negatively correlated with the NPLs while excessive lending (measured by loan-to-asset ratio and the past growth rate of banks' lending) leads to higher NPLs.

Messai and Jouini (2013) investigated the determinants (macroeconomic and bank-specific variables) of the NPLs for a sample of 85 banks in three countries (Italy, Greece and Spain) in the period from 2004 to 2008 using the panel data method. The results suggest that the improvement in the real economy is generating a reduction in the NPLs portfolios. Concerning the unemployment and real interest rate, there is a positive and significant relationship with the ratio of the NPLs while there is a significant and negative relationship between the return on assets (ROA) and the amount of the NPLs. Finally, the results indicate a positive and significant relationship between the variable loans losses reserves and the NPLs.

Shingjergji (2013) analyzed the impact of the main macroeconomic variables on the NPLs level in the Albanian banking system using quarterly data in the period from 2005 to 2012 and a simple regression model. Obtained results indicate a positive relationship between the GDP growth and the NPLs ratio what is contrary to international evidence. The inflation rate is found to be negatively related with the NPLs ratio while there is a positive relationship between the base interest rate of four quarters lag and the NPLs ratio in time *t*. Also, the results suggest the existence of a positive relationship between foreign exchange rate Euro/ALL and the NPLs ratio.

Shingjergji and Shingjergji (2013) analyzed the NPLs in the Albanian banking system for the period from March 2000 to March 2012 using a simple regression model. They found that the effect of the macroeconomic situation plays an important role in the determination of the NPLs. The results indicate a positive relationship between the ratio of the loans on the bank's assets and the NPLs while the relationship between the real interest rate and the ratio of the NPLs is found to be weak. Furthermore, there is a positive relationship between the growth of the loans and the NPLs while the real exchange rate is found to be positively related with the NPLs according to which the international competition of a country is an important determinant of the credit risk. Hence obtained results indicate a negative relationship between the NPLs and the GDP but a positive effect in the time of GDP_{t-1}. Finally, there is a negative relationship between the inflation and the NPLs. The credit growth, inflation and the growth in GDP are found to be insignificant in explaining the NPLs in Albania.

Makri, Tsagkanos and Bellas (2014) analyzed the factors (macro and micro variables) affecting the NPLs of Eurozone's banking systems in the period from 2000 to 2008 using the difference generalized method of the moments (GMM difference) estimation. Their findings reveal strong correlations between the NPLs and various macroeconomic and bank-specific factors. In particular, bank-specific variables capital ratio (bank capital and reserves to total assets) and ROE (return on equity) are negatively correlated while the NPL_{t-1} is positively associated with loan quality. In addition, macroeconomic variables public debt as % of GDP and unemployment were also found to be positively and significantly related to the NPLs. Annual percentage growth rate of GDP denoted a significant negative relationship while

ROA, loans to deposit ratio, the budget deficit/surplus as a percentage of GDP and annual average inflation did not show any significant impact on the NPLs ratio.

Škarica (2014) analyzed the determinants of the changes in the NPLs ratio in selected European emerging markets (Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Romania and Slovakia) using quarterly data in the period from September 2007 to September 2012 and a panel data techniques. The results suggest that the primary cause of high levels of the NPLs is the economic slowdown, which is evident from statistically significant and economically large coefficients on GDP, unemployment and the inflation rate.

The rest of the paper is structured as follows. Section 2 presents the result of conducted empirical analysis and provides the policy implications while Section 3 gives the concluding remarks.

Croatian National Bank (2015) estimated various macroeconomic credit risk models for the corporate and the household sector in Croatia using quarterly data in the period from March 2004 to december 2013 and the ordinary least squares (OLS) models. For the corporate sector, the results show that favorable macroeconomic conditions (measured by economic growth) or increase in prices (measured by inflation and real estate prices) through an increase in corporate income reduces the share of the non-performing placements and off-balance sheet liabilities. In contrast, an increase in interest rates or exchange rate depreciation against the euro increases the burden of loan repayment and increases the share of the non-performing placements and off-balance sheet liabilities as well as the rise in unemployment rate. For the household sector, the results show that exchange rate depreciation against the euro or the growth of interest rates on housing loans and EURIBOR lead to an increase in the share of the non-performing placements and off-balance sheet liabilities. The same is valid in the case of rising unemployment or in terms of general economic slowdown. In contrast, a higher level of real estate prices lowers the share of the non-performing placements and off-balance sheet liabilities.

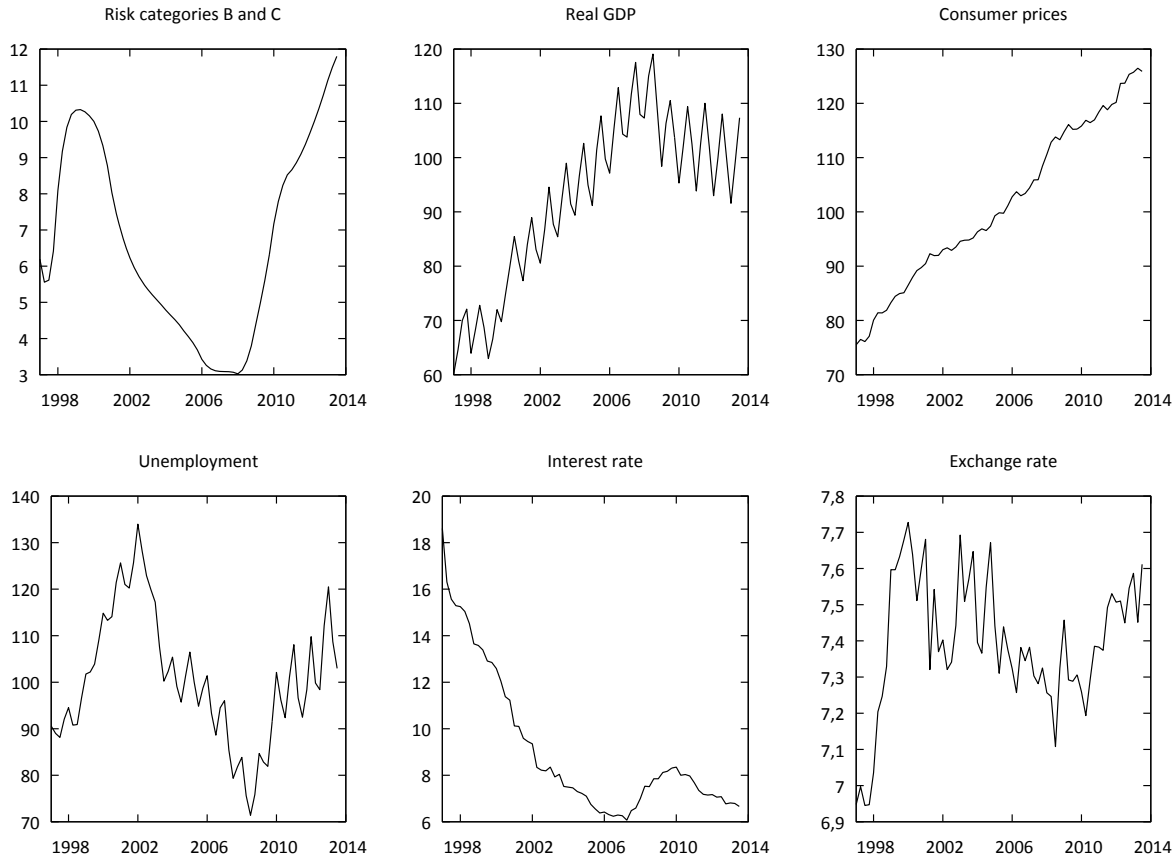
2 Empirical analysis and results

The main goal of this paper is to determine the impact of main macroeconomic variables on the non-performing placements and off-balance sheet liabilities of Croatian banks by using the bounds testing (ARDL) approach for cointegration of time series. Data of six selected variables are observed on a quarterly basis in the period from March 1997 to September 2013 and Graph 1 shows their movement, i.e. the movement of the non-performing placements and off-balance sheet liabilities (RISK_bc)[4], real GDP index (RGDP), consumer price index (CPI), unemployment index (UNEMP)[5], interest rate on kuna credits indexed to foreign

[4] The non-performing placements and off-balance sheet liabilities are calculated as the share of placements and off-balance sheet liabilities classified in risk categories B-1, B-2, B-3 and C in total placements and off-balance sheet liabilities. Since CNB does not announce quarterly data on the share of the non-performing placements and off-balance sheet liabilities in total placements and off-balance sheet liabilities from 1997, but only annual, the annual data are interpolated into quarterly using the "interpolate higher frequency values" method. To check the robustness, interpolated values are then compared with the quarterly data on the share of the non-performing loans to total gross loans for the period from June 2006 till June 2014 taken from the International Financial Statistics – Financial soundness indicators database (International Financial Statistics, 2014). The similarity in their movements is clearly visible suggesting the acceptability of the applied interpolation method. Likewise, the CNB announce the quarterly data on partly recoverable and fully irrecoverable loans only since December 2008.

[5] Represents the number of unemployed persons.

currency (INT_c)[6] and the nominal exchange rate of Croatian kuna against the euro (HRK_EUR)[7]. Data are taken from the Croatian National Bank (Croatian National Bank, 2014b, 2014c), the International Financial Statistics (International Financial Statistics, 2014a) and the Institute of Economics, Zagreb (The Institute of Economics, Zagreb, 2014) databases.



Graph 1: Non-performing placements and off-balance sheet liabilities (in percentage), real GDP index (2005=100), consumer price index (2005=100), unemployment index (2005=100), interest rate on kuna credits indexed to foreign currency (in percentage) and the nominal exchange rate of Croatian kuna against the euro

It is noticeable that most of the series have two break points. First, at the end of the 90s mainly due to the introduction of VAT, second banking crises, democratic elections and second, during 2008 due to the spill over effect of global crisis on the Croatian economy. Likewise, it is visible that the increase in the non-performing placements and off-balance sheet liabilities is accompanied by decline in GDP, rising unemployment, rising interest rate and the depreciation of the exchange rate. Commonly, higher real GDP usually translates into higher income which improves the debt servicing capacity of borrowers and lowers the level

[6] Data on interest rate on kuna credits indexed to foreign currency are taken as a proxy variable for interest rate on credits/placements since CNB does not announce overall average interest rate on credits/placements of Croatian banks.

[7] The largest number of granted credits/placements by Croatian banks is in kuna indexed to euro (or in euros) (Croatian National Bank, 2014a).

of the non-performing placements and off-balance sheet liabilities. The impact of inflation may be twofold. Higher inflation can make debt servicing easier by reducing the real value of the loan but it can also reduce the borrowers' real income when wages are sticky. Additionally, in the case of floating interest rate, higher inflation can also lead to higher interest rates. An increase in the unemployment is expected to influence negatively the cash flow of households and increase their debt burden which in turn raises the level of the non-performing placements and off-balance sheet liabilities. Similarly, it is expected that an increase in unemployment may signal a decrease in production and a drop in demand for firms which may lead to a decrease in revenues and deterioration in the debt condition. In the case of floating interest rate, an increase in interest rate should increase debt burden caused from rising interest rate payments which would ultimately lead to a higher level of the non-performing placements and off-balance sheet liabilities. The exchange rate depreciation might have a negative impact on the borrowers' asset quality, especially in countries with a large amount of lending in foreign currency which, as in the case of rising interest rate, affects the ability to service the debt and therefore could lead to a higher level of the non-performing placements and off-balance sheet liabilities. This is especially emphasized in periods of crisis when due to insufficient foreign exchange reserves, currency depreciations increases the debt servicing costs in local currency terms for borrowers with loans denominated in foreign currency.

To estimate the non-performing placements and off-balance sheet liabilities equation the ARDL modeling approach is used. Due to its advantages the approach was popularized with the works of Pesaran, Shin and Smith (1996) and Pesaran and Shin (1999). The main advantage of this approach is that it can be applied irrespective of whether the regressors are $I(0)$ or $I(1)$ and can avoid the pre-testing problems associated with the standard cointegration analysis which requires identification of the order of integration. In fact, other cointegration techniques such as residual-based methods or Maximum Likelihood approaches presume that variables under consideration are first-difference stationary (or are integrated of order 1). Likewise, it is well known that underlying standard unit root tests have low power, i.e. they often cannot distinguish between true unit-root processes and near unit-root processes. Insight into Graph 1 indicates that certain variable(s) may be stationary in levels (integrated of order $I(0)$) and therefore the use of the ARDL modeling approach is found to be suitable.

The ARDL model is performed in two steps. The first step starts with conducting the bounds test for cointegration. In the second step, when cointegration is found, the long-run relationship and the associated error correction model are estimated.

Before proceeding with the bounds test, it is necessary to examine the properties of the time series, i.e. the degree of integration because it is very important to determine whether the variables are integrated of order n = 0, 1, 2 as to avoid spurious results. In the presence of $I(2)$ variables the computed F-statistic and W-statistic are not valid because the bounds test is based on the assumption that the variables are $I(0)$ or $I(1)$. To do so, ADF test (Dickey and Fuller, 1979), PP test (Phillips and Perron, 1988) and KPSS test (Kwiatkowski, Phillips, Schmidt and Shin, 1992) are considered. To eliminate the influence of seasonal factors all series were seasonally adjusted[8]. Furthermore, all variables, excluding the non-performing

[8] Using the Arima X-13 method.

placements and off-balance sheet liabilities and interest rate, are expressed in logarithms. Results of unit root tests are showed in Table 1[9].

Variable and test	*Level*		*First difference*	
	Constant	*Constant and trend*	*Constant*	*Constant and trend*
ADF test	*t-stat.*			
RISK_bc	-2,626681	-0,550282	-3,454801	-3,859671
LRGDP	-2,591288	-0,635113	-7,362762	-8,060082
LCPI	-1,802498	-2,854339	-6,099540	-6,337248
LUNEMP	-2,275613	-2,346289	-2,916046	-2,891983
INT_c	-2,822790	-1,601455	-3,052388	-5,513523
LHRK_EUR	-3,475072	-3,480993	-9,835292	-9,812855
PP test	*Adj. t-stat.*			
RISK_bc	-0,610804	-0,479300	-2,737515	-2,741657
LRGDP	-2,516777	-0,628339	-7,416385	-8,060082
LCPI	-1,924224	-2,589940	-6,109552	-6,343777
LUNEMP	-1,615074	-1,686818	-3,084209	-3,061512
INT_c	-5,439495	-3,308471	-8,085694	-9,161500
LHRK_EUR	-3,061879	-2,965309	-9,731328	-9,724186
KPSS test	*LM-stat.*			
RISK_bc	0,220282	0,221723	0,308312	0,158098
LRGDP	0,857204	0,255326	0,587882	0,054115
LCPI	1,062408	0,098679	0,259430	0,082948
LUNEMP	0,213998	0,127554	0,152319	0,151863
INT_c	0,773581	0,258391	0,809867	0,189454
LHRK_EUR	0,112511	0,113616	0,164800	0,130391
Perron test	*t-stat.*			
INT_c	-3,914783	-3,473898	-7,163239	-7,409441
LHRK_EUR	-4,676848	-4,224615	-11,00350	-11,09568

Table 1. Unit root tests[10]

It is noticeable that ADF test, PP test and KPSS test indicate a possible stationarity of the interest rate and the exchange rate in levels. However, considering that series might have brakes (Graph 1), Perron test (Perron, 1997) for series with structural break is performed and presented in Table 1. The results clearly reject this possibility. Therefore, for the purposes of

[9] In the analysis Gretl (Cottrell and Lucchetti, 2007), EViews (IHS Global Inc., 2014) and Microfit 5.01 (Pesaran and Pesaran, 2009) econometric software were used.

[10] Note: "*L*" indicates logarithm of the variable. For the implementation of ADF test the Akaike information criterion has been implemented. ADF test critical values (MacKinnon, 1996); constant: 1% level (-3,49), 5% level (-2,89), 10% level (-2,58); constant and trend: 1% level (-4,04), 5% level (-3,45), 10% level (-3,15). PP test critical values (MacKinnon, 1996): constant: 1% level (-3,49), 5% level (-2,89), 10% level (-2,58); constant and trend: 1% level (-4,04), 5% level (-3,45), 10% level (-3,15). KPSS asymptotic critical values (Kwiatkowski-Phillips-Schmidt-Shin, 1992); constant: 1% level (0,739), 5% level (0,463), 10% level (0,347); constant and trend: 1% level (0,216), 5% level (0,146), 10% level (0,119). Perron test critical values (Perron, 1997): constant: 1% level (-5,92), 5% level (-5,23), 10% level (-4,92); constant and trend: 1% level (-6,32), 5% level (-5,59), 10% level (-5,29).

the analysis it can be concluded that all the series are integrated of order $I(1)$, i.e. they are stationary in their first differences.

As stated before, the first step of ARDL approach starts with conducting the bounds test for cointegration. Therefore, the long-run relationship between the variables is tested by computing the F-statistic and W-statistic for testing the significance of the lagged levels of the variables in the error correction form of the underlying ARDL model.

Since the observations are quarterly given, the maximum order of lags in the ARDL model is 4 and furthermore, the trend is included[11]. The error correction version of the ARDL (5, 5, 5, 5, 5, 5) model is defined as follows:

$$\begin{aligned} DRISK\_bc_t = {} & a_0 + a_1 t + \sum_{i=1}^{4} b_i DRISK\_bc_{t-i} + \sum_{i=1}^{4} d_i DLRGDP_{t-i} + \sum_{i=1}^{4} e_i DLCPI_{t-i} \\ & + \sum_{i=1}^{4} f_i DLUNEMP_{t-i} + \sum_{i=1}^{4} g_i DINT\_c_{t-i} + \sum_{i=1}^{4} h_i DLHRK\_EUR_{t-i} \\ & + \delta_1 RISK\_bc_{t-1} + \delta_2 LRGDP_{t-1} + \delta_3 LCPI_{t-1} + \delta_4 LUNEMP_{t-1} + \delta_5 INT\_c_{t-1} \\ & + \delta_6 LHRK\_EUR_{t-1} + u_t \end{aligned} \quad (1)$$

where δ_1, δ_2, δ_3, δ_4, δ_5 and δ_6 are the long-run multipliers, b_i, d_i, e_i, f_i, g_i and h_i are the short-run dynamic coefficients, a_0 is the intercept term, t is a deterministic time trend while u_t are serially uncorrelated residuals with zero mean.

The current values of dLRGDP, dLCPI, dLUNEMP, dINT_c and dLHRK_EUR are excluded since it is not possible to know *a priori* whether LRGDP, LCPI, LUNEMP, INT_c and LHRK_EUR are the "long-run forcing" variables for the non-performing placements and off-balance sheet liabilities (RISK_bc).

Next, F-test and W-test are conducted for the joint hypothesis that the lagged levels of the variables in Equation (1) are zero:

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0 \quad (2)$$

against the alternative hypothesis that at least one lagged level variable is non-zero:

$$H_1 : \delta_1 \neq 0, \delta_2 \neq 0, \delta_3 \neq 0, \delta_4 \neq 0, \delta_5 \neq 0, \delta_6 \neq 0 \quad (3)$$

Computed F-statistic and W-statistic should be compared with the critical values in Pesaran, Smith and Shin (1996). The distributions of F-statistic and W-statistic for testing the existence of the level relationship in the ARDL model are non-standard and must be computed by stochastic simulations. Two sets of asymptotic critical values are provided; one set assuming that all the variables in the model are $I(1)$ and another set assuming that they are all $I(0)$. If the computed F-statistic and W-statistic exceed the upper bound, the null hypothesis of no long-run relationship can be rejected without needing to know whether the variables are $I(0)$ or $I(1)$, or fractionally integrated. If they fall below the lower bound, the null hypothesis of no long-run relationship can be accepted without needing to know whether the variables are $I(0)$

[11] The comparison of the information criterions (R-BAR Squared Criterion, AIC – Akaike Information Criterion, SBC – Schwarz Bayesian Criterion and HQ – Hannan-Quinn Criterion) showed that higher values of the information criterion achieve models that include a trend.

or *I*(1), or fractionally integrated. Finally, if they fall between these two bounds, the result is inconclusive and depends on whether the variables are *I*(0) or *I*(1), and so the unit root tests on the variables may be carried out. For the sake of the analysis, *F*-statistic and *W*-statistic together with their critical value bounds at 90 and 95 percent levels are computed automatically through the program procedure and are summarized in the Table 2.

F-statistic	*95% Lower Bound*	*95% Upper Bound*	*90% Lower Bound*	*90% Upper Bound*
20,4243	3,4101	4,6497	2,8850	4,0291
W-statistic	*95% Lower Bound*	*95% Upper Bound*	*90% Lower Bound*	*90% Upper Bound*
122,5461	20,4607	27,8984	17,3101	24,1749

Table 2: Testing for existence of a level relationship among the variables in the ARDL model[12]

Since the computed *F*-statistic and *W*-statistic exceed the upper bounds, the null hypothesis of no long-run relationship between RISK_bc, LRGDP, LCPI, LUNEMP, INT_c and LHRK_EUR can be rejected irrespective of the order of their integration. The results also suggest that LRGDP, LCPI, LUNEMP, INT_c and LHRK_EUR can be treated as the "long-run forcing" variables for the explanation of the non-performing placements and off-balance sheet liabilities (RISK_bc).

In the second step, the ARDL long-run model is estimated using the AIC[13]. Table 3 summarizes the diagnostic tests of the selected ARDL (2, 4, 4, 3, 4, 3) non-performing placements and off-balance sheet liabilities equation.

Test Statistics	*LM Version*	*F Version*
Serial Correlation: *Lagrange multiplier test of residual serial correlation*	CHSQ(4) = 2,8853, Prob. = 0,577	F(4,32) = 0,38398, Prob. = 0,818
Functional Form: *Ramsey's RESET test using the square of the fitted values*	CHSQ(1) = 1,8179, Prob. = 0,178	F(1,35) = 1,0399, Prob. = 0,315
Normality: *Based on a test of skewness and kurtosis of residuals*	CHSQ(2) = 2,2994, Prob. = 0,317	-
Heteroscedasticity: *Based on the regression of squared residuals on squared fitted values*	CHSQ(1) = 0,59748, Prob. = 0,440	F(1,61) = 0,58405, Prob. = 0,448

Table 3: Diagnostic tests of the ARDL (2, 4, 4, 3, 4, 3) non-performing placements and off-balance sheet liabilities equation

Diagnostic tests suggest that the model is adequately estimated and that the conclusions of the model are acceptable.

[12] Note: The critical value bounds are computed by stochastic simulations using 20.000 replications.

[13] The model using the AIC is estimated since it provides higher values of the information criterion and smaller estimated standard errors in comparison with the SBC and H-Q criterion while the R-BAR Squared criterion selects the same model as the AIC.

The level relationship, i.e. the long-run ARDL (2, 4, 4, 3, 4, 3) non-performing placements and off-balance sheet liabilities equation is presented in Table 4.

Dependent variable: RISK_BC				
	Coefficient	*Std. Error*	*T-Ratio*	*Prob.*
LRGDP	-0,19038	0,026701	-7,1303	0,000
LCPI	0,031397	0,072838	0,43105	0,669
LUNEMP	0,028766	0,010644	2,7027	0,010
INT_c	0,75895	0,12663	5,9932	0,000
LHRK_EUR	0,14531	0,040312	3,6046	0,001
INPT	0,21434	0,22654	0,94614	0,350
TREND	0,0021827	0,4989E-3	4,3754	0,000

Table 4: Estimated long-run coefficients of the ARDL (2, 4, 4, 3, 4, 3) non-performing placements and off-balance sheet liabilities equation[14]

Estimated long-run coefficients are generally statistically significant and have expected signs. It is evident that an increase in real GDP reduces the level of the non-performing placements and off-balance sheet liabilities of Croatian banks wherein an increase in unemployment, prices, interest rate and the depreciation of the Croatian kuna exchange rate lowers their level. The prices are found to be insignificant in the long-run which is not surprising since in the past period inflation in Croatia was very stable because of the efforts of the CNB in the maintenance the price stability. Calculated *t*-ratios suggest that real GDP is the most significant factor in determining the non-performing placements and off-balance sheet liabilities equation, which is followed by interest rate, exchange rate and unemployment. Therefore, performed econometric analysis suggests that real GDP was the main driver of the non-performing placements and off-balance sheet liabilities in Croatia during the past years. As so, a drop in economic activity is the most important risk for bank asset quality.

The error correction representation of the ARDL (2, 4, 4, 3, 4, 3) model together with the model statistics is presented in Table 5.

Dependent variable: dRISK_BC				
	Coefficient	*Std. Error*	*T-Ratio*	*Prob.*
dRISK_BC_1	0,59324	0,076097	7,7958	0,000
dLRGDP	-0,020968	0,0057123	-3,6707	0,001
dLRGDP_1	0,030364	0,0075716	4,0103	0,000
dLRGDP_2	0,020947	0,0064151	3,2653	0,002
dLRRGDP_3	0,017086	0,0060512	2,8236	0,007
dLCPI	0,013167	0,022719	0,57955	0,565

[14] Note: "*L*" indicates logarithm of the variable.

dLCPI_1	-0,030767	0,020080	-1,5322	0,133
dLCPI_2	0,0062578	0,019029	0,32886	0,744
dLCPI_3	0,043424	0,018165	2,3906	0,021
dLUNEMP	0,0074935	0,0065537	1,1434	0,260
dLUNEMP_1	-0,013277	0,0071674	-1,8524	0,071
dLUNEMP_2	-0,0082213	0,0065868	-1,2481	0,219
dINT_c	0,12425	0,057665	2,1546	0,037
dINT_c_1	-0,10367	0,056421	-1,8374	0,073
dINT_c_2	-0,12640	0,052888	-2,3900	0,022
dINT_c_3	-0,053387	0,044457	-1,2009	0,237
dLHRK_EUR	0,0025783	0,010740	0,24006	0,811
dLHRK_EUR_1	-0,028729	0,010947	-2,6244	0,012
dLHRK_EUR_2	-0,024193	0,0094681	-2,5552	0,014
dTREND	0,6505E-3	0,1698E-3	3,8313	0,000
ecm(-1)	-0,29801	0,030027	-9,9248	0,000
R-Squared = 0,98441		R-Bar-Squared = 0,97315		
S.E. of Regression = 0,6828E-3		F-Stat. F(21,41) = 108,2388, Prob. = 0.000		
Mean of Dependent Variable = 0,8464E-3		S.D. of Dependent Variable = 0,0041667		
Residual Sum of Squares = 0,1678E-4		Equation Log-likelihood = 387,4642		
Akaike Info. Criterion = 360,4642		Schwarz Bayesian Criterion = 331,5319		
DW-statistic = 1,8228				

Table 5: Error correction representation of the ARDL (2, 4, 4, 3, 4, 3) non-performing placements and off-balance sheet liabilities equation[15]

It is evident that changes in the first, second and third lag in Real GDP (dLRGDP_1, dLRGDP_2 and dLRRGDP_3), except a change in the current lag (dLRGDP) which is statistically significant and negative, have statistically significant and positive effect on the change in the non-performing placements and off-balance sheet liabilities (dRISK_BC). Regarding prices, only a change in the third lag (dLPRICE_3) has a statistically significant and positive effect on the change in the non-performing placements and off-balance sheet liabilities (dRISK_BC). Onwards, only a change in the first lag of unemployment (dLUNEMP_1) has a statistically significant and negative effect on the change in the non-performing placements and off-balance sheet liabilities (dRISK_BC). Change in the current lag of interest rate (dINT_c) which is positive, has statistically significant effect on the change in the non-performing placements and off-balance sheet liabilities (dRISK_BC) while changes in other lags (dINT_c_1 and dINT_c_2), except the change in the third lag (dINT_c_3), have statistically significant and negative effect. Finally, changes in the first and second lag of the Croatian kuna exchange rate (dLHRK_EUR_1 and dLHRK_EUR_2) have

[15] Note: "*d*" indicates first difference, while "*L*" indicates logarithm of the variable.

statistically significant and positive effect on the change in the non-performing placements and off-balance sheet liabilities (dRISK_BC) while the change in the current lag (dLHRK_EUR) is insignificant. Likewise, it is noticeable that almost all coefficients, except those beside changes in interest rate, are very small.

The error correction coefficient (ecm(-1)) is statistically highly significant, has the correct sign and suggests a moderate speed of convergence to the long-run equilibrium. Nearly 30% of the disequilibria of the previous quarter's shock adjust back to the long-run equilibrium in the current quarter.

Conducted empirical analysis confirmed the theoretical assumptions and is evident that obtained results support other work in this area as previously discussed in the literature review. Therefore, main Croatian macroeconomic variables affect the level of the non-performing placements and off-balance sheet liabilities which are often considered as a key factor in banking and financial crises. To avoid crises, effective bank management and regulatory/supervisory institutions should be able to recognize and quantify these effects. This is a necessary precondition for implementation of an adequate prudential and monetary policy measures for reducing the level of the non-performing placements and off-balance sheet liabilities. Hence, bank managers together with the Croatian fiscal and monetary authorities should find ways to increase foreign investments and economic activity, reduce unemployment and keep the interest rate and the exchange rate stable.

The findings in this paper, especially the results regarding the statistical relationship between main macroeconomic variables and the non-performing placements and off-balance sheet liabilities, may be used to develop a framework for better measuring and assessing credit risk as an important element of Croatian financial stability. Furthermore, scientific contribution is also reflected in improving of existing macroeconomic credit risk models developed by the CNB or individual credit institutions and for improving analytical framework in testing the resistance of Croatian credit institutions on different shocks.

At the end, it is necessary to mention that this analysis has limitations namely because it does not take into account all (or other) variables that affect non-performing placements and off-balance sheet liabilities, both at the macro and micro level.

3 Conclusion

The non-performing placements and off-balance sheet liabilities are often considered key factors that lead to banking crises. Economic and financial crises increase the level of the non-performing placements and off-balance sheet liabilities which can cause significant losses for banks. The loan's portfolio quality can deteriorate as a result of internal (bank-specific) and external factors (macroeconomic). Many studies showed that this deterioration is primarily driven by macroeconomic developments.

The aim of this study was to determine the impact of main macroeconomic variables on the non-performing placements and off-balance sheet liabilities of Croatian banks. For this purpose the bounds testing (ARDL) approach for cointegration was applied. The results indicate the existence of stable cointegration relationship between the variables i.e. in the long-run, an increase in real GDP reduces the level of non-performing placements and off-balance sheet liabilities of Croatian banks wherein an increase in prices, unemployment, interest rate and the depreciation of the Croatian kuna exchange rate increases their level. However, prices have proved to be insignificant. On the other hand, in the short-run the

results are rather mixed. The error correction coefficient is statistically highly significant and suggests a moderate speed of convergence to the long-run equilibrium.

Therefore, to avoid crises, effective bank management and regulatory/supervisory institutions should be able to recognize and quantify these effects. This is a necessary precondition for implementation of an adequate prudential and monetary policy measures for reducing the level of the non-performing placements and off-balance sheet liabilities.

Finally, findings in this paper may be used to develop a framework for measuring and assessing credit risk as an important element of Croatian financial stability.

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Modeling Attributes for Forecasting B2B Opportunities Acquisition

Marko Bohanec
Salvirt d.o.o., Slovenija

Mirjana Kljajić Borštnar
University of Maribor, Faculty of Organizational Sciences, Slovenia

Marko Robnik-Šikonja
University of Ljubljana, Faculty of Computer and Information Science, Slovenia

Abstract

Key element for any solution in knowledge discovery and decision support is a solid description of a particular field or domain. A powerful set of attributes (features, descriptors) is needed to secure as complete as possible description of an individual case. We focus on creating a list of attributes, referenced in academic papers as indicators of business-to-business sales opportunities. Although the related papers are rare, we created a list of more than 75 attributes of different categories. To enable better understanding and faster adoption, we list domains of attributes. The list is open for further addition of attributes reflecting specific context of sales organization. This first step needs to be further extended with data preprocessing and application of machine learning techniques to generate problem insight.

Keywords: business-to-business, B2B, attributes features, machine learning, data mining, and knowledge discovery, knowledge engineering.

1 Introduction

Machine learning techniques are highly dependent on input data quality and chosen parameters. Internal mechanics of techniques are different, however, all depend on the quality of attributes and their values to describe the domain in focus. We are focusing on a business-to-business (B2B) sales domain, specifically we would like to develop a comprehensive list of attributes, describing sales opportunities, by reviewing academic papers and previous research. The purpose of created list of attributes is aimed to support data set knowledge engineers in building data structures for sales opportunities, as a preparation for machine learning. Outcome of machine learning is transparent representation of what makes opportunity a good opportunity. Such an insight is given as feedback to the sellers to increase selling learning curve and support their prioritization of sales opportunities.

The paper is related to a broader research of B2B sales forecasting with application of machine learning techniques, however we are not covering broader context; rather we focus on relevant attributes. Please consult papers of Bohanec, 2014a and 2014b for a broader description of the research topic.

2 Methodology

Academic databases were searched for articles dealing with description of industry project acquisition, business-to-business relationships foundations and attempts to model sales opportunities. B2B sales expert opinions and nominations were also taken into account to complement academic findings with practical knowledge. Found attributes were grouped into five categories.

3 Literature review

The seminal research conducted by Monat (2011) was identified as the most important review of articles in this field. Beside systemized list of attributes and determinants, one of Monat's key finding is a fact that there is "surprising paucity of literature regarding characterization of sales leads, and no predominant unifying theory has emerged - furthermore, corroborative data are almost non-existent" (Monat, 2011, pp. 179). This is further extended with identification of principal weakness of existing lead characterization models being the fact that they are not based upon sound theoretical underpinnings and have not been validated. The systematization of attribute categories serves in our review as an important starting point.

Important research in the area of drivers of sales performance was done by Churchill in 1985. Recent study by Verbeke et al. (2011) builds upon work of Churchill and classification scheme for sales determinants devised by Walker (1977). According to their research the following drivers demonstrate significant relationships with sales performance: selling related knowledge, degree of adaptiveness, role ambiguity, cognitive aptitude and work engagement. From perspective of our research they can be grouped into individual capabilities of seller's and internal organizational characteristics.

D'Haen and Van den Poel (2013) have proposed a model to generate high quality list of prospects that are easier to convert into leads and ultimately clients. Their motivation was to help sales representatives, which based on available information use arbitrary rules to select leads to pursue. The proposed model standardizes customer acquisition framework and emphasizes the iterative nature of the process.

Rieg (2010) identified the uncertainty coming from external environment as a significant reason why there is no evidence on increased forecasting accuracy despite improved statistical methods and organizational learning capabilities. We summarize his findings in one attribute, reflecting external environment stability.

Zallocco et al. (2009) present a qualitative study of performance measures with interviewees. They propose a method for organizing performance measures as a framework of crossing effectiveness/efficiency with internally-externally-focused measures to cover the complexity of different dimensions (sales training, behavior, etc.) in sales. Their research indicated a gap between performance attributes researches focus on and what occurs in the world of sales.

Ng and Liu (2000) have, as part of their research, collected a list of attributes identified as important sales lead indicators. They were motivated to prevent "data overload but information starvation", which is also our motivation in searching for the right balance between data collection and ability to comprehend insight into the learning cycle.

An approach for developing sales forecast based on estimated probability distributions of sales closures was presented by Duran, 2008. He incorporated noisy information into a model and quantified the uncertainty of the inputs as an area to improve forecasts, which is useful information to leverage, when building model machine learning model.

Lee et al. (2011) developed a new cognitive map inference mechanism, which is not dependent on artificial assumptions, so called case-based reasoning multi-agent cognitive map – CBRMCM. Their idea is to convert factors (in our context features, attributes) into intelligent agents, which monitor changes in their relationships to other agents and report their changes to connected node agents. They applied this mechanism to the analysis of sales opportunities, creating interesting list of attributes.

4 The attributes

We have collected academic papers, which contributed to the list of attributes, determinants, features and other form of B2B sales leads characteristics. The attributes were reviewed and grouped into five groups to reflect some commonalities and secure easier navigation between them. All groups together serve as a starting point for a particular company building their learning data set for predictive data mining. For data mining algorithms, the input data is very important. Below we list important findings, related to selection and preparation of data (Maaß et al., 2014):

1. The right preparation method can unveil important information hidden in the available data and decrease the perceived variance and uncertainty.
2. Prediction algorithms have no control over the quality of the features (attributes) and must accept it as a source of error.
3. The process to find right data preparation techniques is dependent on the insight and knowledge created during the process of data preparation and application of learning algorithms.
4. ML techniques advantage is to unveil more complex patterns compared to other forecasting methods, however they need attributes at right aggregation level to avoid superimposition of the noise and users distrust (also in Alvarado-Valencia and Barrero, 2014)

We aim to build a model, which will be used by sales forecasters, therefore from the very beginning we want to create understandable and high quality solution to secure acceptance by the users (Smith and Mentzer, 2010). Therefore we propose a comprehensive list of attributes, which were found to characterize sales leads in business-to-business context. For every company a subset list can be selected based on expert opinion. The selection of attributes needs to describe a particular deal in an understandable way in order to maintain trust to the approach.

We propose grouping the attributes to following five categories related to:

1. Client economy: describing situation of a client.
2. Individual seller: describing traits of a seller.
3. Internal: describing internal interpretation of the opportunity.
4. Relationship: describing nuances of B2B relationship.
5. External: describing economic stability.

Client - related attributes

The list in Table 1 reflects attributes related to situation of a client.

Opportunity attribute description	Values	Authors
Prospect authority to sign deal	Low; Mid; High	Monat
Deal size	Real	D'Haen &V. den Poel; Lee et al.
Number of Employees	Integer	D'Haen &V. den Poel
Site Employees	Integer	D'Haen &V. den Poel
Industry Type	Std. categories	Bohanec
Company size(revenue)	Real	D'Haen &V. den Poel
Opportunity Name	String	Bohanec
Competitors	NA; No; Yes	Monat; Duran
Import export indicator	No; Yes	D'Haen &V. den Poel
Manufacturing indicator	No; Yes	D'Haen &V. den Poel
Public private indicator	No; Yes	D'Haen &V. den Poel
Legal status code	Code categories	D'Haen &V. den Poel
Small business indicator	No; Yes	D'Haen &V. den Poel
Fortune_1000_indicator	No; Yes	D'Haen &V. den Poel
Non-profit indicator	No; Yes	D'Haen &V. den Poel
Franchise indicator	No; Yes	D'Haen &V. den Poel
Client utilize external services	No; Yes	Bohanec
Budget allocated	No; Yes	Duran; Monat
Formal tender	No; Yes	Bohanec
Request for information	No; Yes	Bohanec
Request for proposal	No; Yes	Bohanec
Client growth dynamics	Shrinking; Slow_down; Stable; Growth;Fast_Growth	Bohanec
Decision timeframe	Fast; normal; after_negotiations; not_known	Duran; Monat
Short listed notifications	No; Yes	Duran
Pre-engagement funded (for pilot)	No; Yes	Duran
Pilot opportunity	No; Yes	Bohanec
Verbal confirmation on selection	No; Yes	Duran
Written confirmation on selection	No; Yes	Duran
Product service client dissatisfaction revealed	No; Yes	Monat
Positive prospect statements on vendor	No; Yes	Monat
Payment collection	Hist_credit_issue; Non_Std_condit; No_issue_expct	Lee et al.
Location	Remote; Urban; Bus_center	Bohanec

Table 1 - Client - related attributes

Individual

The list in Table 2 reflects attributes related to individual seller.

Opportunity attribute description	Values	Authors
Technical knowledge	Low; Mid; High	Zallocco et al.
Presentation skills	Low; Mid; High	Zallocco et al.
Communication skills	Low; Mid; High	Zallocco et al., Verbeke et al.
Listening skills	Low; Mid; High	Zallocco et al., Verbeke et al.
Teamwork	Low; Mid; Strong	Zallocco et al.
Sellers ID	Seller's Name	Bohanec
Past performance	Underperf.; achieved; Overperf.	Verbeke et al.
Adaptiveness	Low; Slow; Fast	Verbeke et al., Piercy
Role person match	missmatch; acceptable; well_match	Verbeke et al

Table 2 - Individual attributes

Internal

The list in Table 3 reflects attributes related to internal seller's organization.

Oppt Attribute	Values	Authors
Opportunity ID	Integer	Bohanec
Source	referral; event; joint_past; online_form; direct_mail; (and others)	Monat
Client status	Current; New; Past	Monat
Our understanding of client business	Low; Mid; High	Piercy
Product/Service ID	Industry specific prod	Bohanec
Longest stage days	# days in longest stage	Bohanec
Stage where deal was longest	1;2;3;4 (or more)	Bohanec
Discount percentage	Integer	Bohanec
Customer segmentation	Predefined segments	Bohanec
Project risk	Low; Mid; High	Lee et al.
Contract type	Time&Matr; Fixed_price; Monthly_rate; Year_prepay	Lee et al.
Difficulty of implementation	Hard; Regular; Easy	Lee et al.
Scope clarity	Low; Few_Questions; Clear	Lee et al.
Impact on next opportunity	Low; Reference; High	Lee et al.
Resource availability	Not_avial; Some_chall;Avail	Lee et al.
Margin expected	<10%; 10-20%; 20-30%; >30%	Lee et al.

Delivery execution	No_issue; Caution_req; Difficlt_exe; Expct_very_diff	Lee et al.
Strategic deal	Unimport_deal; Avg_import; Very_impot_deal	Lee et al.
Financial sense	Not_good; small_marg_coll_issues; small_rev_no_problems; good_conditions	Lee et al.
Sales Opportunity Index (perception about status of this opportunity)	Red; Amber; Yellow; Green	Lee et al.
Compelling Event	No; Yes	Bohanec
Channel partner name	Name	Bohanec
Channel partner status	Basic; Silver; Gold	Bohanec
Channel partner rating	Weak; Normal; Strong	Bohanec
Sales process velocity	Stalled; Slow; Normal; Fast	Bohanec
Influence on other clients	Low; Mid; High	Ng et al.
Cross-sale	No; Yes	Bohanec
Up-sale	No; Yes	Bohanec

Table 3 - Internal attributes

Relationships

Table 4 contains attributes related to nuances of relationship between prospect and seller.

Opportunity attribute description	Values	Authors
Needs defined	Poor; No; Info_gathering; Yes	Monat
Benefits articulated by client	No; Some; Solid; Well	Bohanec
Providing Info	No; Partial; Full	Monat
Negotiations	Easy, Moderate, Tough	Duran
Familiarity with Vendor	No; Yes	Monat
Attitude to client	Bad_client; Normal; First_deal; Strat_ account	Lee et al.

Table 4 - Relationships related attributes

External factors

Opportunity attribute description	Values	Authors
Market stability	Low; Mid; Stable	Rieg
External supply stability	Low; Mid; Stable	Bohanec
Supporting Infrastructure stability	Low; Mid; Stable	Bohanec
Country rating (e.g. OECD)	Low; Mid; High	Robnik-Šikonja
Interest rates	Low; Normal; High; very high	Robnik-Šikonja

Regional stability	Unstable; Some problems; Stable	Bohanec
Buying power (vs EU average)	Lower; Average; Higher	Bohanec
EUR vs. USD trend	Dropping; Stable; Rising	Bohanec

4.1 Application of attributes – an example

After selecting a list of attributes, we can build a training data set. Based on a context of the selling company we select those attributes, which seem to provide a solid description of sales opportunities. It is important to note that the outcome of each individual opportunity (as they reflect sales history) needs to be included, *Signed* in our case in Figure 1. In order to detect opportunities likely to be closed, we prefer a balanced learning data set in terms of both outcome classes.

We use an attribute menu to select a subset of attributes and build the training data set reflecting past experience with selling services and products.

	Extr_stabil	Source	Cntr_type	Imp_not_oppt	Existing_client	Sales_veloc	External_svcs	Budg_alic	Client_growth	Need_defined	Competitors	Prospect_authority	Familiary_wVendor	Product	Pilot	Deal_size	Signed
1	Mid	Referal	Year_prepay	Low	No	Fast	Yes	No	Growth	Info_Gathering	No	Mid	Yes	A	No	5000	NO
2	Mid	Joint history	Year_prepay	Low	No	Stalled	No	No	Growth	No	Yes	High	No	A	No	6000	NO
3	Mid	Joint history	Year_prepay	Low	No	Slow	No	No	Stable	no	no	Mid	Yes	B	No	1800	NO
4	Mid	Referal	Year_prepay	Low	No	Fast	Yes	No	Growth	Yes	No	Mid	No	AB	No	5000	NO
5	Mid	Referal	Year_prepay	Low	No	Slow	Yes	No	Stable	Info_Gathering	Yes	Mid	No	A	Yes	8000	NO
6	Mid	Event	Year_prepay	Mid	No	Normal	Yes	Yes	Stable	Yes	No	Mid	No	A	Yes	8000	NO
7	Mid	Referal	Year_prepay	High	No	Normal	Yes	No	Stable	Yes	No	High	No	AB	Yes	10000	NO
8	High	Referal	Year_prepay	High	No	Slow	No	Yes	Fast_Growth	Yes	No	Mid	No	AB	Yes	10000	NO
9	Mid	Event	Year_prepay	High	No	Slow	Yes	Yes	Growth	Info_Gathering	Yes	High	No	B	Yes	3500	NO
10	Mid	Event	Year_prepay	Low	No	Normal	No	Yes	Stable	Info_Gathering	No	Mid	No	A	Yes	6000	NO
11	Mid	Newspaper	Year_prepay	Mid	No	Slow	Yes	No	Slow_Down	Yes	No	Mid	No	B	No	1800	NO
12	Mid	Invite	Time&Mater	Mid	No	Slow	Yes	Yes	Slow_Down	Yes	No	High	Yes	D	No	1500	NO
13	Mid	Joint history	Year_prepay	Low	No	Normal	Yes	Yes	Growth	Info_Gathering	No	Mid	Yes	A	Yes	7000	NO
14	Mid	Joint history	Year_prepay	High	No	Normal	Yes	No	Stable	Info_Gathering	No	Mid	No	A	Yes	8000	NO
15	High	Referal	Year_prepay	High	No	Fast	No	No	Fast_Growth	Yes	No	High	No	A	No	3000	YES
16	High	Referal	Year_prepay	Low	No	Fast	No	No	Fast_Growth	Yes	No	High	No	B	No	3000	YES
17	Mid	Event	Year_prepay	High	No	Slow	Yes	Yes	Growth	Yes	No	High	No	A	Yes	10000	YES
18	Mid	Joint history	Year_prepay	Low	Yes	Fast	Yes	Yes	Slow_Down	Yes	No	High	No	A	Yes	5000	YES
19	Mid	Joint history	Monthly_rate	Low	Yes	Fast	Yes	Yes	Stable	Yes	No	High	Yes	G	Yes	15000	YES
20	High	Joint history	Time&Mater	High	No	Fast	Yes	Yes	Growth	Yes	No	High	Yes	E	Yes	8000	YES
21	High	Joint history	Year_prepay	High	No	Slow	Yes	Yes	Fast_Growth	Yes	Yes	High	Mid	AB	Yes	5700	YES
22	High	Referal	Year_prepay	High	No	Fast	Yes	Yes	Growth	Yes	No	High	No	AB	Yes	12000	YES
23	Mid	Invite	Time&Mater	Low	Yes	Fast	Yes	Yes	Fast_Growth	Yes	No	High	Yes	D	Yes	1000	YES
24	Low	Joint history	Year_prepay	High	No	Slow	Yes	Yes	Slow_Down	Yes	No	High	Yes	AB	Yes	2000	YES
25	Mid	Joint history	Time&Mater	High	Yes	Normal	Yes	No	Growth	Yes	No	High	Yes	F	No	1500	YES
26	High	Referal	Time&Mater	Low	Yes	Normal	Yes	Yes	Stable	yes	No	High	Yes	H	No	2000	YES

Figure 1 - selection of attributes - demo example

In the next step we assess attributes by ranking them according to their information value. We use Orange machine learning suite (orange.biolab.si) and stack-rank attributes with different metrics as shown in Figure 2. We note that top 8 or 9 attributes represent majority of information, so the rest of attributes could be removed without significant implication on the learning outcome. This is an important insight, as one of the goals of the model is to achieve balance between parsimony and comprehensiveness of the data.

	Attribute	#	ReliefF	Inf. gain	Gain Ratio	Gini
1	Prospect_authority	2	0.628	0.496	0.517	0.133
2	Extr_stabil	3	0.257	0.246	0.233	0.077
3	Existing_client	2	0.158	0.254	0.360	0.069
4	Need_defined	5	0.144	0.383	0.268	0.099
5	Cntr_type	3	0.114	0.138	0.149	0.043
6	Imp_nxt_oppt	3	0.107	0.143	0.102	0.038
7	Client_growth	4	0.044	0.110	0.057	0.036
8	Product	8	0.036	0.224	0.092	0.062
9	Sales_veloc	4	0.026	0.181	0.103	0.057
10	Deal_size	C	0.009	0.063	0.032	0.021
11	Competitors	3	-0.047	0.065	0.076	0.018
12	External_svcs	2	-0.064	0.015	0.019	0.005
13	Familiary_wVendor	3	-0.075	0.092	0.079	0.028
14	Budg_allc	2	-0.077	0.078	0.079	0.026
15	Source	5	-0.084	0.077	0.040	0.023
16	Pilot	2	-0.097	0.007	0.007	0.002

Figure 2 - attributes ranking (Orange machine learning suite)

Different scoring techniques in **Figure 2** are used for a ranking. ReliefF is a popular measure due to its ability to detect conditional dependencies between attributes and provide a unified view on the attribute estimation in regression and classification. In addition, their quality estimates have a natural interpretation (Robnik-Šikonja and Kononenko, 2003). Technique *Inf. gain* is measuring information entropy of attributes (prefers those with more values), *Gain Ratio* balances attributes toward those with less domain values (Witten et al., 2011) and *Gini* index, criterion which prefers attributes that put the largest class into one pure node (Hall, 1999).

5 Discussion

The review of academic work in the field of business-to-business selling is the key point of this paper. This topic is context sensitive and soft in the sense of expert's ability to formulate attributes and its values. Experts from a focus company need to be included. McCarthy Bryne et al. (2011) show in their research that industrial sales people have considerable insight to provide to the sales forecasting process, if their input is properly managed, rewarded and supported by the management of the sales forecasting process. To overcome this trust issue, sales management needs to create a positive environment and encourage sales people to participate and discuss insights of machine learning models from the very beginning of the process. This creative and iterative process should generate new attributes, which can be added to the list of attributes and followed through the complete predictive data mining process to discover their added value. The process shall take dynamic context of environment into account. Changes need to be reflected in updated attribute list and data set to avoid concept drift due to outdated view of sales dynamics for a specific company.

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Use of Quantitative and Qualitative Criteria for Selection of Investment Projects in Water Distribution Systems

Marjan Brelih
Eltec Petrol d.o.o., Slovenia
marjan.brelih@eltec-petrol.si

Uroš Rajkovič
University of Maribor, Faculty for Organizational Sciences, Slovenia
uros.rajkovic@fov.uni-mb.si

Tomaž Ružič
Eltec Petrol d.o.o., Slovenia
tomaz.ruzic@eltec-petrol.si

Abstract

This article presents an innovative approach to selection of investment projects for effective water management and management of water distribution systems. Goals, which we pursue in this kind of project, are management of the client's assets, reduced production of the production-technical risks, minimizing the costs of the current investment maintenance and reduced operating costs. Selection of the suitable projects must meet the main criteria, such as financial aspect of the project, final success in accordance with contract requirements and deadlines, and dissemination of knowledge in co-operation with the client. The list of selection criteria was determined by an expert group. The goal was to design a multi-criteria decision model that takes into account both quantitative and qualitative criteria. Our model combines different types of utility functions, such as weighted sum or simple what-if rules. It also enables defining conversion functions from qualitative to quantitative value domains and back. The result is an overall assessment for each project consisting of both discrete class value and a numeric grade that helps distinguish small differences among options that fall in the same class. This evaluation is based on complex rules and is derived from original input data. The proposed approach makes it possible to carry out different types of analysis. Such a tool helps the decision maker to better understand the results and to make better decisions.

Keywords: multi-criteria decision model, quantitative and qualitative criteria, effective water utility management

1 Introduction

With the population growth, the usage of water is more essential day by day, and because of that, deficit of drinking water will or rather is a growing problem. Even though 71% of our

Planet's surface is covered with water, only one percent of that is for actual drinking (USGS, 2015). We, people with our everyday activities in the industry, agriculture and household, burden the environment with a variety of chemicals, additionally contributing to the deterioration of the quality of the drinking water. Additional problems, which are arising from the past history and are worsening the condition, are uneconomical planning and the construction and poo maintenance of the distribution network. All of this leads to the loss of drinking water on the distribution route from the water source to the consumer at the end. Water looses amount to 40 per cent in different regions and/or cities worldwide (Komunala Kranj, 2013; Growing Blue, 2012; EPA, 2010). All these losses, in addition to other costs of acquisition and distribution of water, are fully covered by consumers. In addition to the above, we should not and cannot ignore us, the end users/consumers, who with our uneconomical use of the drinking water additionally worsen the situation.

Listed problems need to be addressed in the initial phase of designing, and then in the construction and reconstruction of water supply systems, and later in resource management, distribution and usage of the drinking water. For that purpose, we were invited by the company that deals with reducing water loss, to build a model, in order to enhance transparency in the selection of projects, perform an analysis of the risks and consequences in the selection, and consequently maximize the revenue of the company. Projects of the economical resource management, distribution and consumption of the drinking water, can be a multi-year projects (with a duration of one to 10 years), involving a large group of performers, so the wrong decisions can have a long-term economic consequences, for a company offering its services, as well as for the operator of the water supply systems.

2 Methods

One of the most important skills that we all need to learn in life is quick, quality and confident decision making (Cooper, 2014). Decision making is a natural process that must be treated as scientific activity and is defined as selecting one of the several alternatives (Saaty, 2012). Our alternatives are projects, which are made to technically and economically optimize the distribution of the water supply network. Out of the eight projects, we have chosen three for the needs of the article, and these three projects belong to different operators of the water supply systems. The projects were named P1, P2 and P3. The projects were evaluated according to three main criteria (Figure 1), which contain criteria about the investment for the project of the client, and data, necessary to carry out the project. The mentioned criteria are divided into other sub criteria, all the way to the basic criteria that are measurable. Together they make a tree of criteria (Figure 2).

The systematic evaluation of the projects is the most sensible approach. It is reasonable to support our decisions problem with an appropriate methodology because the problem is very complex and consequences are important (Tsoukias, 2008). In such case, we have to rethink our decision and consult about it, as the decision makers are responsible for the consequences of the decision. Awareness of the consequences has led us to create a decision-making model for the selection of the most appropriate investment projects in water supply systems.

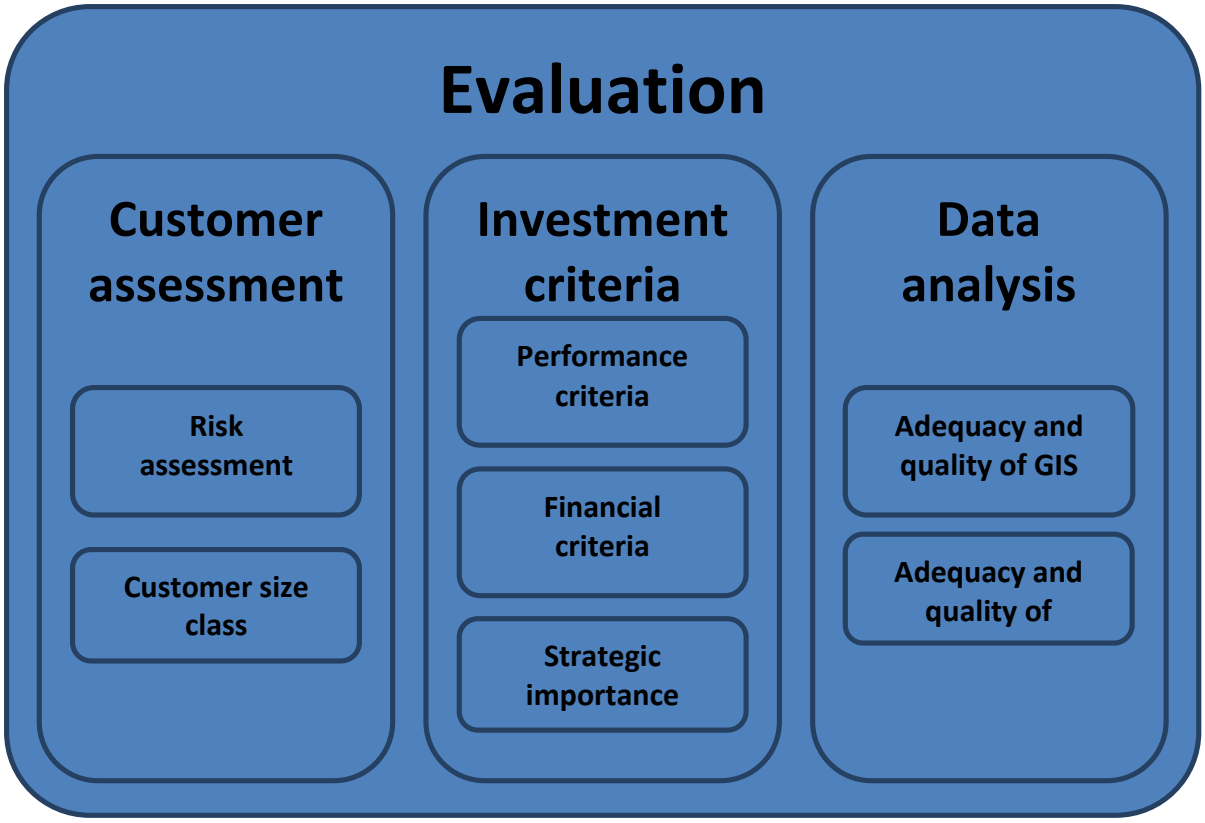

Figure 1: Distribution of the criteria on the first levels of the tree structure.

3 Creating tree of criteria

With a group of experts from the fields of management of water supply systems, information technology, marketing, project management and financial accounting department, we have defined criteria for pursuing the above mentioned objectives. We selected certain criteria, which were structured in a tree of criteria. In the process of constructing a tree of criteria, it became clear, that in order to manage our decision-making problem, the model must combine both types: quantitative and qualitative criteria. After the experts confirmed the selection and structure of the tree of criteria, we started to determine the value domains and thus type for each criterion. Domain values were determined according to the requirements in the tender documents and based on past experiences with similar projects.

A tree of criteria is shown in Figure 2. It consists of 33 criteria, of which 12 are aggregated and 21 are basic criteria. The basic criteria are those which do not have any criteria underneath and represent the criteria by which we describe alternatives. Symbol 1 indicates the criteria with qualitative value domains, and symbol a indicates the criteria with quantitative value domains. Figure 2 presents tree structure together with the description and value domain for each of the criterion in the tree structure. Quantitative value domains additionally contain units for clarification of values. Value domains are arranged from the worst to the best. Worst values are coloured red, best are coloured green.

For the basic criteria “Customer profiles”, “Sales data” and “Operation data”, the value domains illustrate the evaluation of the relevance and quality of the data as a percentage. The criterion of “GIS” illustrates the percentage of adequacy and soundness of geographical information system.

Tree of criteria	Description	Value domain [unit]
Evaluation	Final evaluation	**unacc.,** acc., good, ***excel.***
Customer	Customer assessment	**unacc.,** acc., good, ***excel.***
Risk	Risk business assessment	**high,** med., ***low***
Shareholders	Shareholders structure	**private,** mixed, ***public***
Payment habits	Customer ability to pay	**defaulting,** irregular, ***regular***
Risk assessment	The assessment of the risk	**high,** med., ***low***
Size class	Customer size class	**unacc.,** acc., good, ***excel.***
Enterprise size	Company size category	**micro,** small, med., ***large***
Employees	Assessment of properly trained employees	**unacc.,** acc., good, ***excel.***
Number	Number of assigned employees	**0** – ***25*** [people]
Structure	Educational structure of employees	**unacc.,** good, ***excel.***
Availability	Working hours per week	**0** – ***40*** [hour]
Investment	Investment assessment	**unacc.,** acc., good, ***excel.***
Performance	Performance assessment	**unacc.,** good, ***excel.***
Contract model	Type of contract model	**purchase,** installation, ***optimization***
Contractor	Contractor structure	**subcontr.,** mixed, ***own***
Deadline	Project deadline	**0** - ***60*** [months]
Finance	Financial construction assessment	**unacc.,** acc., good, ***excel.***
Funding	Available funding sources	**credit,** fee, ***cohesion***
Bank guarantee	Size of bank guarantee	**1000** - ***0*** [monetary unit]
Profitability	Expected profitability	**unacc.,** acc., good, ***excel.***
Effectiveness	Effectiveness points criteria	**0** – ***100*** [points]
Excellence	Excellence points criteria	**0** – ***100*** [points]
Strategic importance	Strategic importance evaluation	**low,** med., ***high***
Buyer	Buyer type	**existing,** new cust., ***new market***
Collaboration	Collaboration type	**purchase only,** short-term, ***long-term***
New research	Developing new services	**none,** partial, ***new study***
Data	Adequacy of data	**unacc.,** acc., good, ***excel.***
GIS	Adequacy and quality of GIS	**0** – ***100*** [%]
Process data	Adequacy and quality of process data	**0** – ***100*** [%]
Operation data	Adequacy and quality of operation data	**0** – ***100*** [%]
Sales data	Adequacy and quality of sales data	**0** – ***100*** [%]
Customer profiles	Adequacy and quality of customer profiles	**0** – ***100*** [%]

Figure 2: The tree of criteria with criteria definitions and value domains

The criterion “New research” illustrates whether we have to develop new services during the development, and in what proportion. The criterion “Collaboration” presents the type of cooperation, whether the particular alternative is a purchase only, or is it short-term or long-term cooperation. The criterion “Buyer” has the value domain that distinguishes between the existing customer, new customer and whether we are entering a new market by undergoing a project.

The financial criteria “Effectiveness” and “Excellence” contain a numerical value of points, which illustrate the indicators of performance and profitability. Both are internal measures that company has been using for a long time. The criterion “Bank guarantee” describes the amount of bank guarantees required and the criterion “Funding” illustrates the source of money for financing the project.

“Deadline”, “Contractor” and “Contract model” criteria present the number of months needed to implement the project, the structure of the contractor and the type of contract respectively. “Contract model” describes the whether the project is about purchasing of the equipment only or it requires us to supply and install the equipment or if it is about technical and economical optimization of water distribution systems.

Employees were evaluated with three criteria “Number”, “Structure” and “Availability”, which surveyed the number of employees available, the relevance of the educational structure for the project collaboration, and their availability in number of hours.

The projects are long-term and for the successful production, the company must input a lot of resources, both financial and human, for the implementation of the project. For that reason the basic criteria “Shareholders”, “Payment habits” and “Risk assessment” assess the risks of the project. “Risk assessment” is determined by sales and financial experts, “Payment habits” place the client in the class of defaulting payer, irregular payer or regular payer, and the ownership structure “Shareholders” describes whether it is a private, mixed or public ownership.

4 Criteria aggregation

In order to use quantitative and qualitative criteria in the same type of a model, we have to use various aggregation functions. The following cases illustrate some of the implemented features.

4.1 Weighted sum

For example of combining quantitative criteria by using the weighted sum, we use the aggregate criterion “Process data”, which combines three subordinate criteria “Operational data”, “Sales data” and “Customer profiles”. All sub criteria have quantitative value domains and are equally important for the decision. We expressed the equal importance using weights of 1/3 for each of the 3 criteria. The general formula is illustrated by the equation:

$$\begin{aligned} \mathrm{ProcessData}_{P_i} = {} & \mathrm{OperationData}_{P_i} * W(\mathrm{OperationData}) + \\ & \mathrm{SalesData}_{P_i} * W(\mathrm{SalesData}) + \\ & \mathrm{CustumerProfiles}_{P_i} * W(\mathrm{CustumerProfiles}) \end{aligned}$$

, where W(x) represents the weight of the criterion x and xp represents assessment of the alternative P for criterion X. We have used a similar method of grouping for the criterion “Data”, using weights of 77 per cent for “GIS” and 23 per cent for “Process data”.

4.2 If-then rules

This type of aggregation function is known from the methodology DEX (Bohanec et. al, 2013). For all combinations of the value domains of the subordinate criteria, we have to choose an appropriate value domain of the superior criterion. Consider the aggregate criterion "Strategic importance", for example. It is divided into three subcategories: "Buyer", "Collaboration" and "New Research". Each one of them has a 3-point scale:

$$\text{Buyer}_{\text{V.D.}} = \{\text{existing}, \text{new cust.}, \text{new market}\}$$
$$\text{Collaboration}_{\text{V.D.}} = \{\text{purchase only}, \text{short term}, \text{long term}\}$$
$$\text{NewResearch}_{\text{V.D.}} = \{\text{none}, \text{partial}, \text{new study}\}$$

Here is an example for easier understanding of a single rule:

IF Buyer Is existing
  AND Collaboration Is $\text{purchase}_{\text{only}}$
  AND NewResearch Is none
THEN StrategicImportance Is low

There are 27 rules or combinations. They are defined as the Cartesian product:

$$\text{Buyer}_{\text{V.D.}} \times \text{Collaboration}_{\text{V.D.}} \times \text{NewResearch}_{\text{V.D.}}$$

The algorithm used to display the aggregated rules, as we know it from the program DEXi (Bohanec, 2014; Bohanec et. al., 2013; Žnidaršič, Bohanec & Zupan, 2008), has merged 27 simple rules into 11 aggregated rules, which are shown in Figure 3. The first rule means that a combination of existing "Buyer", short-term or worse "Collaboration" and partial or worse "New research" represents low "Strategic importance". From the first two rules it is shown, that low "Strategic importance" (worst value) is possible only in cases when it comes to the existing "Buyer". With other values for the criterion "Buyer", the "Strategic importance" would be med. or high, irrespective of the other two criteria.

Rule	Criteria			
	Buyer	**Collaboration**	**New research**	**Strategic importance**
1	**Existing**	<= short-term	<= partial	**low**
2	**Existing**	*	**none**	
3	**Existing**	<= short-term	***new study***	
4	**existing**	***long-term***	partial	
5	new cust.	<= short-term	<= partial	med.
6	new cust.	*	**none**	
7	>= new cust.	**purchase only**	<= partial	
8	*	***long-term***	***new study***	
9	>= new cust.	*	***new study***	***high***
10	>= new cust.	***long-term***	>= partial	
11	***new market***	>= short-term	*	

Legend: >= better or equal to <= worse or equal to * any value

Figure 3: Aggregation if-then rules for the criterion "Strategic Importance".

4.3 Conversion of values from quantitative to qualitative

We will present the conversion as an example of combining criteria "Effectiveness" and "Excellence", both has quantitative value domains, into a superior criterion "Profitability" which has qualitative value domains. We have considered two options:

- using an aggregation function on quantitative values, such as a weighted sum followed by transformation of quantitative results to qualitative values or
- firstly transforming input values from quantitative into qualitative values and then using an aggregation function on qualitative values.

This example describes the second option. Prior to using an aggregation function with if-then rules, we have to convert quantitative values into qualitative values.

The criterion "Profitability" has a qualitative value domain defined on interval from 0 to 100 points. We have decided to map these values into four classes (unacc., acc., good, excel.). Figure 4 illustrates the conversion. User defined function shows that a class value good describes quantitative values from interval [38, 50). By using interpolation method we can assign a numeric value inside the qualitative class for every transformed value. Dotted line on Figure 4 shows that a quantitative value of 44 is transformed into the middle of class good. By doing this we can rank different quantitative values that are transformed into the same qualitative class.

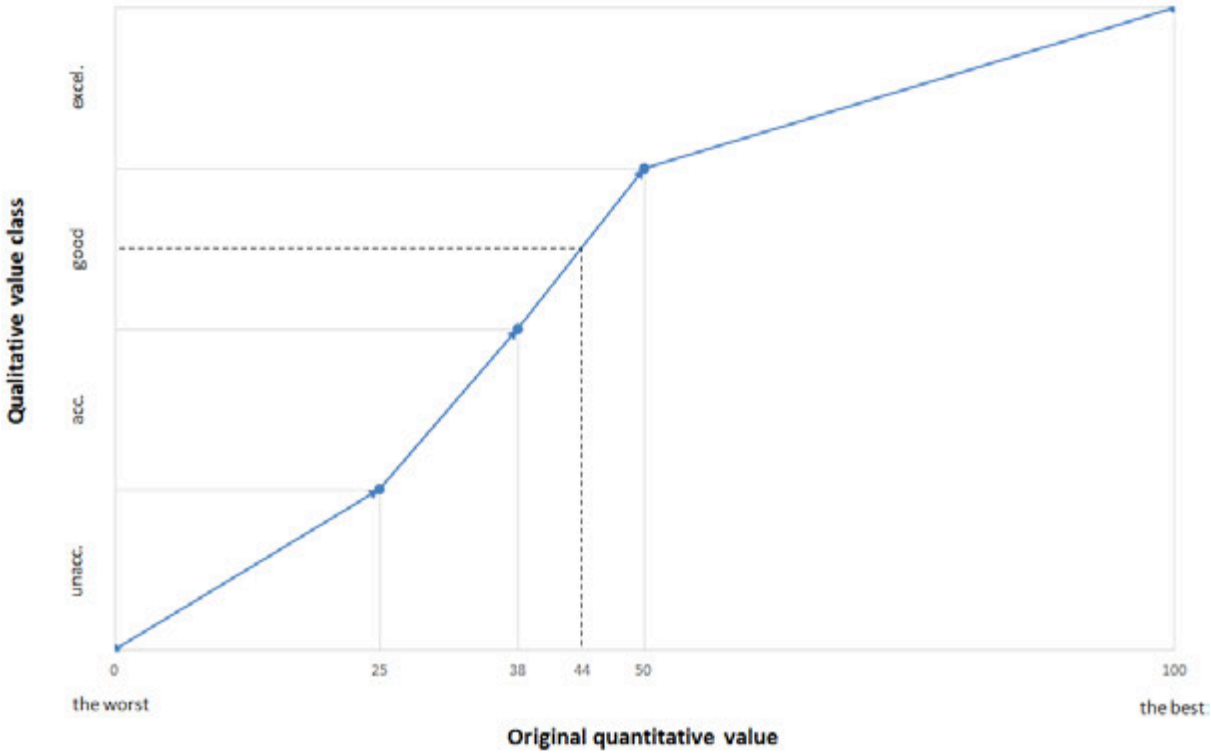

Figure 4: Visual presentation of transformation function that transforms quantitative values for "Profitability" criterion into qualitative value classes

5 Evaluation of alternatives

The next step in the decision process is to input alternatives. We have to estimate the selected projects. This means, we have to determine their values by the basic criteria in the tree criteria (Figure 5).

Criteria	P1	P2	P3
Shareholders	*public*	*public*	*public*
Payment habits	*regular*	*regular*	*regular*
Risk assessment	*low*	med.	medium
Enterprise size	med.	small	*large*
Number	3	1	8
Structure	good	good	*excel.*
Availability	5	1	24
Contract model	installation	installation	installation
Contractor	mixed	*own*	**subcontr.**
Deadline	5	18	24
Funding	*cohesion*	*cohesion*	**credit**
Bank guarantee	675	150	471
Effectiveness	60	68	66
Excellence	35	34	37
Buyer	new cust.	new cust.	*new market*
Collaboration	short-term	short-term	*long-term*
New research	partial	**none**	**none**
GIS	75	80	65
Operation data	94	90	85
Sales data	91	86	75
Customer profiles	80	75	70

Figure 5: Evaluation of alternatives P1, P2 in P3 by the basic criteria

Using aggregation functions and calculating values for aggregate criteria, we obtain the final evaluation for each project. The advantage of the presented decision model is that the use of both quantitative and qualitative types of criteria, preserves original values and, therefore, in addition to qualitative estimation we also gain a quantitative value. Because we preserved all the input data, we can now distinguish between the alternatives in the same class (Figure 6). For every qualitative aggregation function the results consists of a qualitative value and a numeric interval that describes that alternative more precisely. The interval defines the position of the alternative inside the calculated class value. Each class value is described by an interval from 0 to 1 where 0 presents the worst value and 1 presents the best value in that class. By using quantitative values we obtain a single value inside the class as it is shown in Figure 6. By using qualitative values we don't know the exact position inside the class. This uncertainty means that the alternative could be anywhere in that class or, if described by our numeric interval, it could be anywhere on the interval from 0 to 1. This causes that all superior criteria deal with intervals in regard to the numeric presentations inside a class.

Quantitative criteria have numeric values. Some of them have defined conversion functions. An example of a conversion function was previously described and is presented in Figure 4.

Such criteria have both, quantitative and qualitative value domains. Their qualitative values are shown in brackets following a quantitative value that was calculated prior to using a conversion function. Figure 6 shows two such criteria "Profitability" and "Data".

Criteria	P1	P2	P3
Evaluation	***excel.*** (0.38;0.48)	***excel.*** (0.71;0.80)	***excel.*** (0.67;0.76)
Customer	***excel.*** (0.38;0.72)	***excel.*** (0.29;0.62)	***excel.*** (0.57;0.92)
Risk	***low*** (0.16;1.00)	medium (0.00;0.84)	medium (0.00;0.84)
Size class	good (0.51;0.68)	good (0.35;0.52)	***excel.*** (0.66;0.88)
Employees	good (0.18;0.37)	good (0.00;0.19)	***excel.*** (0.42;0.74)
Investment	acc. (0.46;0.71)	***excel.*** (0.46;0.71)	***excel.*** (0.21;0.46)
Performance	**unacc.** (0.47;0.85)	***excel.*** (0.10;0.48)	good (0.26;0.63)
Finance	good (0.24;0.65)	***excel.*** (0.54;0.94)	good (0.57;0.98)
Profitability	47.5 (good)	51 ***(excel.)***	51.5 ***(excel.)***
Strategic importance	medium (0.30;0,86)	medium (0.12;0.67)	***high*** (0.13;0.65)
Data	78.25 (good)	81.05 ***(excel.)***	67.92 (good)
Process data	89.15	84.56	77.7

Figure 6: Evaluations of alternatives by aggregated criteria for P1, P2, P3

From the results in Figure 6 it is evident that projects P1, P2 and P3 fall in the same final assessment – they are all excellent projects. Looking at the quantitative results of the final evaluation, we see that that we can immediately eliminate the project P1, since it is maximum value is lower than the minimum values of the other two projects. For decision makers it is important to understand the decision. Therefore the value of the criteria is not enough.

Figure 7 shows evaluation of the alternatives according to selected criteria. The criterion "Evaluation" shows that all three projects are in the best class, but the project P1 has a lower estimation than the other two. We also see that by criterion "Performance" project P1 is in the worst class. Besides that it is also in a lower class in comparison with P2 and P3 by the "Investment", "Finance" and "Strategic importance" criteria. By no criterion is P1 in a higher class than the other two alternatives. Although the alternative P1 received the best estimation by the "Process data" criterion, which is a quantitative criterion, the discrepancies between the estimations of variations by this criterion seem small. With this explanation, the experts understand the reasons why P1 has not received a better final score.

When comparing alternatives P2 and P3, the difference is not as obvious as it was in the case of P1. By the "Employees" criterion P2 is in a lower class than P3 and consequently also by the "Size class" criterion. But P3 is in a higher class by the "Performance" criterion and, consequently in the context of small differences better by the higher-level "Investment" criterion. Furthermore, by "Data" criterion, some experts exposed the alternative P2 as a superior one compared with P3, which is at the same level of the tree structure as the "Investment" and "Customer" criteria. After reviewing valuations by individual criteria, they unanimously found arguments, that the P2 alternative is the project they want the most in their company.

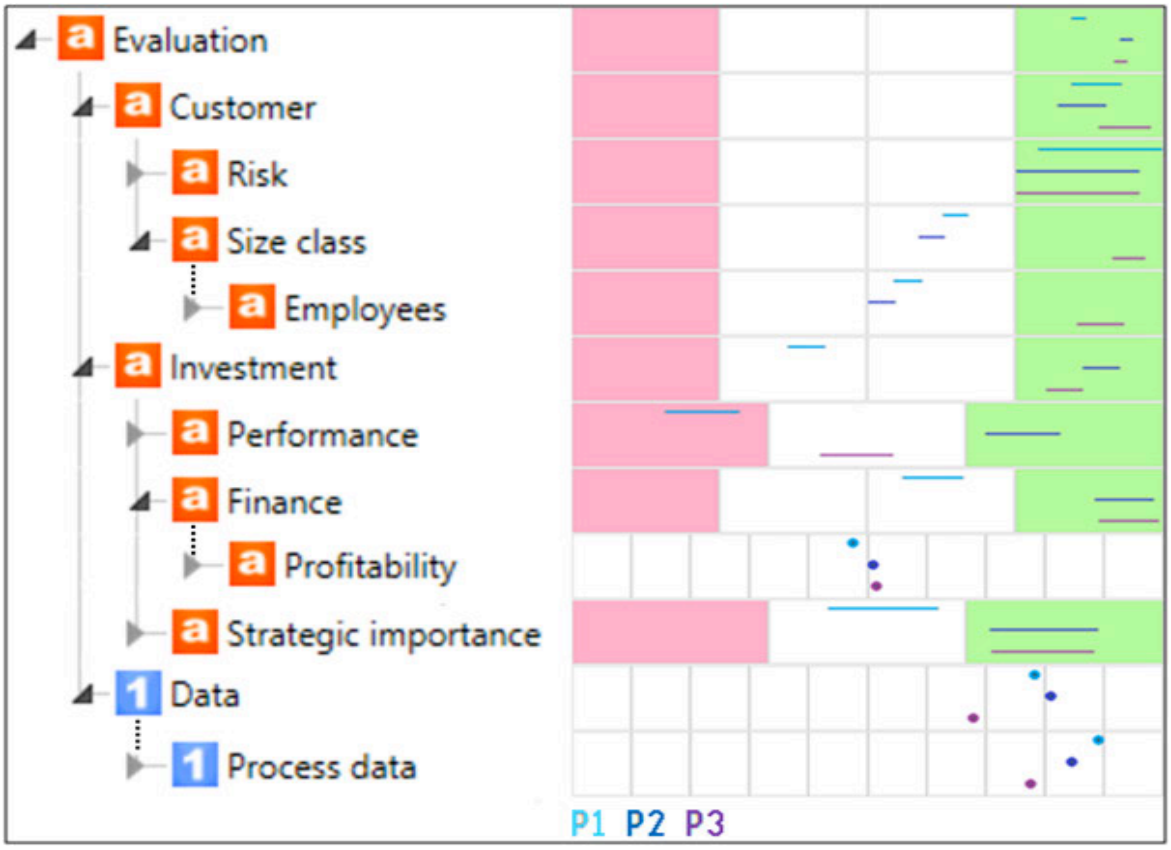

Figure 7: Evaluating alternatives by selected criteria

6 Conclusion

With the proposed solution, we provided a model that preserves natural values of criteria. When we talk about quantitative criteria, the model uses more detailed information, as if we had previously transformed them into qualitative classes. Because of that, this model offers a wider range of utility functions, which facilitates the implementation of rules into the model, as formulated by experts in the decision-making model.

The construction and usage of such model, requires in-depth methodological knowledge for the decision-making group to choose appropriate value domains, transformations and utility functions. It would be expected, that the time complexity of the construction of such models is greater than when using simpler methods.

The understanding of the results didn't present any obstacle for the experts. They showed confidence in the model, which is based on the original values of the criteria without prior conversion. In the small differences they saw the importance of comparison between alternatives.

In the future, we will develop a software solution as the shell of an expert system, which users will be able to independently use for solving their problems. We will offer a sensible combination of methodologies that can substitute some methodologies in a single tool and intertwining them so the decision maker is methodologically burdened as least as possible.

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Interrelationship of Corporate Identity, Corporate Image and Corporate Reputation: a New Stakeholder-Time Based Model

Ana Čuić Tanković
Faculty of tourism and hospitality management, Opatija, Croatia
anact@fthm.hr

Abstract

Corporate identity, corporate image and corporate reputation have attracted interest from a wide range of academic disciplines, due to their intangibility and their importance in building an organization's competitive advantages. This paper examines the constructs of corporate identity, corporate image and corporate reputation, uncovering the considerable confusion and mismatch in their uses present in the literature, due to cross-disciplinary researches and vague distinctive elements. After a systematic terminology and theoretical review, all conceptual models presented in the literature where considered and four of them, presented by imminent authors, were examined. Seeing the discrepancy of development between theory and modelling and because of the indisputable interrelationship of these three constructs constituting corporate marketing, a new two-dimensional model is proposed.

Keywords: corporate identity, corporate image, corporate reputation, stakeholders, time

1 Introduction

The marketing discipline is facing a new paradigm oriented toward the theoretical approach proposed by corporate marketing: this term was first introduced by Balmer (1998), who years later refined his proposal in several subsequent papers (Balmer, 2001, 2009; Balmer and Greyser, 2003, 2006; He and Balmer, 2011; Balmer and Gray, 2003, 2004). The corporate marketing approach reviews the variables in the marketing mix and defines six C's, representing the fundamental concepts to understand this new marketing discipline: character (referred to corporate identity), culture (organizational identity-OI), covenant (corporate branding), conceptualizations (reputation or corporate image), communications (corporate communication) and constituencies (management of stakeholders) (Balmer and Greyser, 2006). The close connection between all these concepts leads to the appearance of numerous approaches to the study of this field in academic literature, which fail to provide a shared and global definition and, in so doing, complicate the understanding of corporate marketing (Christensen and Askegaard 2001; Souiden et al., 2006; Walker, 2010). The constructs most commonly discussed, and whose research is relevant to the fate of any organization, are corporate image, corporate identity and corporate reputation. Even in the professional

literature these constructs often overlap or are misunderstood. This creates problems for academics and practitioners alike, especially in interdisciplinary research, since identity, image and reputation can be considered within a variety of spheres, ranging from public relations, organizational studies, marketing, and corporate governance to design and architecture. In the mid twentieth century, this area became a subject of interest to academics, who made a huge theoretical contribution to the topic. Their work, however, does not exclude the need for continued research, given the growing desire to more clearly define their theoretical outlines and create a better understanding of the concept. Especially evident is the need for reaching a consensus regarding the three constructs and finding a consistent model that would facilitate further research. This paper aims to provide a comprehensive overview of the literature reviewed to help fathom the cause-effect link of the constructs, critically review the models presented, and propose a new model based on recent theoretical and explorative knowledge.

2 Literature review

2.1 Corporate identity

Corporate identity is the articulation of what a company is and how it works. Tied to the way the company carries out its business activities and to the strategies it adopts and implements, corporate identity is also a means of differentiating the company from others (Marwick and Fill, 1997, Balmer and Gray, 2003; Chun 2005). It reflects the unique characteristics or corporate personality deeply embedded in the behavior of the organization's members which helps employees fully identify with the organization (Balmer and Gray 2000). Consequently, there is a gap between perceptions, between "how we see ourselves", reflected in the corporate identity, and "how we would like others to see us", representing desired corporate identity. By distinguishing between intents, main intentions and identity strategies, various aspects of corporate identity have been identified, such as actual identity (Balmer and Greyser, 2002) which differs from organizational identity that is conceived as the subjective perceptions of a company's identity by its internal stakeholders, and is called the perceived identity. Intended identity includes both how the company wants to perceive itself (ideal identity, desired identity) and how it wants others to perceive it (intended image). A distinction can also be made between organizational identity and corporate identity (Balmer and Soenen, 1997, Balmer and Gray, 2003; Chun 2005), with the former being a term of organizational behavior and the latter referring to identity on a strategic level. Hatch and Shultz (2003) explored the distinction between the two terms, and even though both are at the heart of management and both generate differences relative to competitors, organizational identity refers to what the internal stakeholders feel and think about their company while corporate identity refers to how the company operates based on a shared understanding and common goals.

Various authors have tried to formulate all-inclusive definitions of corporate identity. However, because the construct covers a very broad range of an organization's attributes, Perez and del Bosque (2014) analyzed and categorized the definitions according to the dominant attribute described. They singled out five prevailing aspects in the attributes of corporate identity: identity as organizational personality, identity as organizational image, identity as visual image, identity as a collection of corporate communication means, and identity as an integrative concept. Melewar (2003) sees corporate identity as the set of an organization's resources that are characteristic of the organization and summarizes them in a

model containing 21 internal factors, grouped in seven constructs. In their later work, Melewar and Karaosmanoglu (2006) explore the interrelations that make up corporate identity and conclude that corporate culture, resulting from the organization's history, founder, country of origin and sub-cultures and consisting of a mission, vision and values, influences corporate strategy (positioning strategy and differentiation strategy) as well as corporate behavior (company behavior, management behavior, employee behavior). From corporate strategy follows corporate structure for brand structure and organizational structure, which directly affects corporate design (slogan, architecture, office layout, location, website). Corporate strategy, corporate culture, and corporate behavior create corporate communication (marketing, management, organizational communication), which, together with corporate design, creates corporate identity.

It is evident from these constructs that managers and marketers are equally engaged in the domain of corporate identity and are in general agreement concerning the importance of corporate identity as an instrument of strategic management (Alessandri, 2001). Corporate identity management links corporate identity to corporate strategy; corporate strategy meaningfully shapes corporate identity and should be regarded as an integral part of the strategic planning process (van Riel, 1995; Olins 1995; Marwick and Fill, 1997; Balmer and Greyser, 2003, Balmer, 2009, He and Balmer, 2011). A conclusion reached by recent research dealing with the corporate identity/corporate strategy interface (He and Balmer, 2011) is that by using the means of attributing, legitimizing and fine-tuning, board members and other senior managers manage the corporate identity/corporate strategy through the reconciliation of cognitive states that display a degree of dissonance with the strategy. Thus, corporate identity can facilitate and enable strategic changes, innovations and learning. The research also confirmed the importance of vision inspired identities in the context of identity-based views of the firm.

Cornelissen et al. (2007) and Shahri (2012) underline the overriding purpose of corporate identity: to achieve the desired image from the perspective of customers and other stakeholders, with corporate identity being a platform for building this corporate image. Even though a company does not have enough power to directly determine its public image, it may influence its formation through proper management of its business identity (Dowling, 1994; van Riel, 1995; Karaosmanoglu and Melewar, 2006). In this regard, Karaosmanoglu and Melewar (2006) consider that corporate image is formed from the projection of all signs that make up the identity of the company, so that both concepts are closely linked (Hatch and Schultz, 1997; Christensen and Askegaard, 2001). Consequently, business identity has become an increasingly important concept in business (Melewar and Karaosmanoglu, 2006) and its management is a key element of corporate strategy (Melewar et al., 2005) because it is the starting point for forming the corporate image.

2.2 Corporate image

The term corporate image was first used in 1953 by Newman (Abratt, 1989:64) when he formulated the problem of comparing and equating human personality and a company's image. Since then, corporate image has developed alongside emerging sciences in a variety of fields, in particular, corporate communication, corporate management and corporate marketing. As knowledge in these areas grew, the approach to understanding corporate marketing changed, leading to changes in its theoretical delineation: „overall impression produces in the minds of an organization's public" (Barich and Kotler, 1991), "the result of the interaction of all the experiences, impressions, beliefs, feelings, and know-how that people

have about a business" (Worcester, 1997), "overall impression in the minds of customers and original mental image that the audience has of a specific organization" (Gray and Balmer, 1998), "overall impression left on the mind of customers, as a gestalt and as an idiosyncratic cognitive configuration. Although dynamically interrelated with corporate reputation, corporate image i dependent upon a person's beliefs, feelings, ideas, and impressions, and is aided by the information provided by the company, as well as managerial attitudes, behavior, and philosophy" (Richard and Zhang, 2012). It is evident from these definitions that image is a set of perceptions created in the mind of the general public. Image is used to create the personality of a company or a product through preferences and positive attitudes or through negative associations and avoidance tendencies. Image is, therefore, the cognitive picture of a company, formed on the basis of prior attitudes, opinions and notions aligned with actual features. From a psychological perspective, an image represents the tendency to reduce a large number of meanings into a conclusion, template or stereotype, thus simplifying the relationship of individuals towards their environment. Wilkins and Huisman (2014) state that over the years a variety of terms have merged with the corporate image construct: corporate associations and corporate evaluation (Brown and Dacin, 1997), corporate identity (Bhattacharya and Sen, 2003); corporate image (Brown et al., 2006); image (Barich and Kotler, 1991); organizational image (Hatch i Schultz, 1997); organizational reputation (Scott and Lane, 2000); and reputation (Bick, et al., 2003).

Corporate image, translated from the company's identity (what the organization is), is created using the perception of corporate identity projected in the hope of influencing purchase intention, the willingness to invest, or the desire to work in the company (Balmer, 1995; Van Riel, 1995). Abratt (1989:63) argues that organizations "need to make a concerted effort to manage their corporate images" because corporate image management is the key to gaining and keeping public trust. He asserts the necessity of distinguishing between the functional meaning of a company's image (tangible assets of quality, reliability, services, and prices) and its emotive meaning. Many researchers have noted the importance of image, concluding that image influences the way in which people perceive, and react to, certain things (Christensen and Askegaard, 2001; Dowling, 1998; Zaltman, 2003). Image aims to create the personality of a company or product through preferences and positive attitudes or negative associations and avoidance tendencies. Hence, image is a powerful means of communicating with people to entice them to act in a meaningful way, and today image management at the strategic and tactical level of marketing and management is seen as a tool with growing potential.

Wilkins and Huisman (2014:2225) suggest that corporate image is an individual's immediate impression of an organization whereas corporate reputation results from stakeholders' holding consistent corporate images over time. This is conventional wisdom which views corporate reputation from the aspect of time, since reputation is built on the basis of prior experience, while image is subject to change as a result of communicational and other efforts. On the other hand, corporate image and corporate reputation are generally considered as two distinct constructs which may be strongly related. This relationship is intuitively appealing given the idea that image and reputation are two socially constructed entities and derived from the shareholder's perception.

2.3 Corporate reputation

Corporate reputation (Gray and Balmer, 1998:697) "indicates a value judgment about an organization's attributes". Generally, corporate reputation develops over time as a result of consistent performance and intensified effective communication, while corporate image can

be developed more quickly using well-designed communication programs. This explains why the constructs reputation and image are not one and the same, and cannot be used interchangeably, as is sometimes seen in the literature. Markwick and Fill (1997) assert that corporate reputation is a reflection of the historical, accumulated impacts of previously observed identity signs and possible transactional experiences. Other authors (Chun 2005, Dickinson-Delaporte et al, 2010, Hoejmose et al., 2014) also consider that reputation is more enduring than image and represents a fairly consistent resource of good repute and support to positive cases (positive reputation) or distrust and avoidance in adverse situations (negative reputation). Chun (2005) argues that the knowledge collected over the years in this field can be grouped into three schools of thought, each of which differently applies the reputation paradigm. These are the evaluative, impressional and relational schools. The difference between them is based on who are the central stakeholders placed in the focal point, rather than on their field of operation or on an epistemological basis. Stakeholders are often classified as internal (employees and managers) and external (consumers and shareholders). While the evaluative and impressional schools mostly focus on the interests of the individual stakeholder, the relational school is grounded on the stakeholder theory that concedes that different stakeholders may have different expectations regarding the organization. The relational school centers on the opinions of internal and external stakeholders, giving us a new look at building reputation as a construct. Corporate image can change relatively quickly as a result of organizational changes or communication programs, whereas reputation calls for long-term investment, and consistency in all messages communicated. Therefore, to foster investment in corporate reputation it is necessary to ensure image continuity that will create a positive reputation as a precondition to enabling the organization to develop successfully. Corporate reputation may be viewed as a mirror of the organization's history which serves to communicate to its target groups information regarding the quality of its products or services in comparison with those of its competitors. Other authors consider reputation to be related to financial performance (Flanagan et al., 2011), favorable stakeholder behavior (Money el al. 2011), customer trust and purchase intentions (Keh and Xie, 2009). According to Cian and Cervai (2013), reputation as a construct represents an umbrella expression that encompasses corporate image, projected image, organizational identity and all their terminological synonyms such as organizational culture and constructed image. Their model sees reputation as a factor, gathering the opinions of internal and external stakeholders. They also make a distinction between the image communicated within an organization (defined as corporate identity), the image communicated to the external environment (the desired corporate identity) and the corporate image representing a new variable derived from the two aforementioned images.

According to Herbig and Milewicz (1993), an organization can have multiple reputations, one for each attribute, or a global reputation; in this way, corporate reputation is formed as a process that accumulates the judgments over time of the various groups who interact with the organization. Along this same line of thought, Tischer and Hildebrandt (2014) use corporate reputation as an “overall perspective” which includes all external stakeholders (consumers, suppliers, investors, society, partners, the community) and internal stakeholders (owners, managers and employees). Hence, corporate reputation is seen as a “signal to stakeholders” (Hoejmose el al., 2014), in which “credibility” is analyzed: identification of the dimensions that drive stakeholders’ perceptions of the organization is integral to successful reputation management, with the aim of boosting credibility, where managers need to build an understanding of these in order to focus their efforts in building and managing corporate reputation.

3 Model review

Having provided a literature review and explained each concept separately, this paper will present the interrelationship of corporate identity, corporate image, and corporate reputation in creating what has been defined as corporate marketing. For several decades, scholars have been following the development of each construct individually as well as the development of their interrelations. The following section explores the models used in integrating these three, or more, factors into the corporate marketing management process. As it would be presumptuous to attempt to discuss all the models constructed in relation to these constructs,

only conceptual models are taken into consideration, while excluding exploratory models which examine the association between corporate image, customer satisfaction and service quality (Cameran et al. 2010), corporate branding and employees (Foster et al., 2010), corporate image in the leisure services sector (Minkiewicz et al. 2011), and corporate image relative to the elements of service companies (Tubillejas et al. 2011). Also excluded are the conceptual models that consider development through only a single construct of corporate marketing: corporate image management process (Abratt, 1989), corporate identity and organizational performance (van Riel and Balmer, 1997), semiotic perspective of corporate identity and corporate image (Christensen and Askegaard, 1999), corporate communication and corporate image (Cornelissen, 2000), corporate identity and corporate communication (Balmer and Gray, 2000), identity management mix (Balmer 2001), organizational identity and corporate identity (Conelissen et al. 2007), social identity, corporate reputation (Walker, 2011), development of generic corporate identity (Otubanjo, 2012), corporate identity and corporate strategy (Shahri, 2012), corporate identity and environmental forces (Suvatjis et al. 2012), and comprehensive framework for reputation (Cian and Cervai, 2014).

Hence, analyzed are the conceptual models that explain the development of corporate constructs from a theoretical understanding and consider at least two of the three constructs or their terminological versions. These are the models of Marwick and Fill (1997), Grey and Balmer (1998), Stuart (1999), and Chun (2005).

Marwick and Fill's model (1997) presents the major elements of the corporate identity management process (CIMP), its interfaces and prevailing forms of corporative communication. Their graphic synthesis underscores company strategy and strategic management, which plays an important part in building corporate image. In their opinion, if organizations have a personality, strategies will vary with the different type of organizations. Corporate identity will result from organizational development and self-analysis, two elements achieved through managerial communication. Thus, strategic management is a component that must be shown separately if the company's identity is to be clearly understood, developed and managed. The authors highlight the importance of communication, which they divide into marketing communication and management communication, based on van Riel's model (1995). Management communication has a greater impact on the formation of corporate personality and identity, while marketing communication must be involved in building corporate image. Corporate image is generated from corporate identity using planned communication and under the influence of the environment and its unplanned signs beyond the organization's reach. The strength of this model is that it shows the basics of constructing corporate personality – that is, strategic management – and includes communication in the image building process. Its weakness can be seen in the construct of reputation which is not distinctly shown because it is only a part of corporate image. Feedback is relocated from researching corporate image back to the organization's strategic management.

Grey and Balmer's model (1998) builds on that of Marwick and Fill (1997) and is a step forward in exploring the importance of corporate image and corporate reputation. The authors highlight the fundamental elements of this process: "corporate identity" through "corporate communication" creates "corporate image and corporate reputation", which can lead to "competitive advantage", in spite of – or thanks to – "exogenous factors". The model points to the importance of feedback and correction which are crucial if the process is to be effective and which flow from corporate image and corporate reputation towards corporate communication and corporate identity. Corporate communication of any kind is marked as one of the vital factors in building corporate image and reputation, which are completely equal, judging by this graphic presentation,. This equality is the model's downside because it fails to show the difference between these two constructs.

Stuart's model (1999) is an improvement of her earlier model (1998) and a revision of Abratt's model (1998). It comprises 11 elements, each of which has its own supplementary elements: organizational culture is presented as the surrounding area, denoting that it is a context rather than a variable, and it is made up of corporate personality (consisting of the corporate philosophy, the corporate values and corporate mission), corporate strategy (based on management communication, and incorporating top management vision, products and services, organizational structure, and corporate identity structure), corporate identity (containing the mix of behavior, symbolism and the communication plan). The corporate identity/corporate image interface is the breaking point through which interpersonal communication, marketing communication, and management communication affect stakeholders, creating corporate image, which continues to evolve into corporate reputation, which leads to sound financial performance and business survival. Environmental influences are shown as impacting on all parts of the model. In Stuart's model organizational personality and symbols are included under organizational identity, while employees, one the largest ownership-share groups, are placed in the internal part of the model. This indicates that the employees' view of corporate identity is an important part of its management. Corporate personality and identity are tied to strategy, considering that the author sees a company's corporate identity as an expression of its personality which is grounded on strategic management. This model includes a much larger number of constructs and explains corporate image formation and corporate identity management as a reflection of development thinking within the context of corporate marketing and corporate identity management. The model, however, fails to make a distinction between corporate image and reputation, while it fully explains corporate identity.

Chun's model (2005) excels in its simplicity and linearity. As a starting point, the author takes the model of Davies and Miles (1998) which explains the interrelationship of identity-"what the company is", image-"what the customers think it is" and desired identity-"what the company says it is". All these constructs are interrelated, forming a triangle in the center of which gaps emerge between what is communicated and what is perceived. What is important, and what the author speaks in favor of, is the fact that corporate reputation is not just another name for image, but rather an umbrella construct, encompassing identity, desired identity and image. Indeed, the triangle created by these three constructs is called "the elements of corporate reputation". Although this model in its simple form is rarely used as a final model for further research, it clearly provides an unambiguous and concise starting point from which other authors may expand their research efforts. Despite failing to incorporate communications and the element of time, the model represents a turning point in the development of corporate marketing theory because it singles out corporate reputation as a separate unit created beyond the relationships between the other constructs.

Considering the strengths and weaknesses of the models discussed, and with regard to previous knowledge from the literature, there is a need for the proposal of a new conceptual model, encompassing the constructs of corporate identity, corporate image, and corporate communication and explaining them through two dimensions most often referred to in the literature: stakeholders and time (Figure 1).

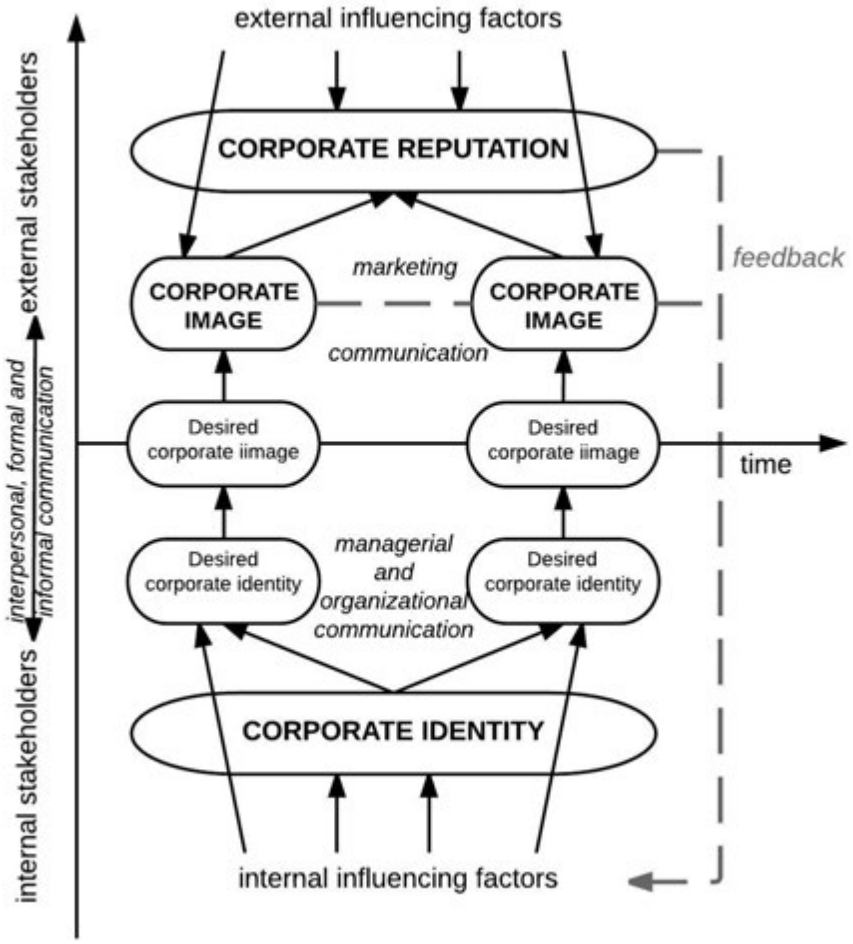

Figure 1: [Proposed model of corporate marketing constructs with variables stakeholders and time], source: author

This model is a graphic presentation of the theoretical knowledge derived from the literature reviewed. In the proposed, two-dimensional model, the y-axis represents the stakeholders, which according to Tischer and Hildebrandt (2014) can be divided into external stakeholders – customers, suppliers, investors, society, partners, and the community – and internal stakeholders – owners, managers, and employees. Corporate identity is a construct shaped by strategic management together with its internal stakeholders and is subject to change because the organization, together with its attributes, is a very vigorous and changeable variable. Corporate identity communicates to the general public the desired corporate identity which becomes the desired corporate image; however, because of external influences and an

increased number of new stakeholders, multiple desired corporate identities generate a single corporate image. Taking into account the historical aspect and time, representing the x-axis, together with previously acquired experience and the competitive environment, corporate reputation is created. From the perspective of the general public, corporate reputation is a construct that can be changed very slowly and with difficulty. Communication is embedded in every process and field of this model and is responsible for the continuous flow of the processes: interpersonal, informal, and formal communication between internal and external stakeholders; managerial and organizational communication within the organization and internal stakeholders; and marketing communication among external stakeholders. Feedback flows from the acquired picture of corporate image and corporate reputation to internal influencing factors that are the starting point for further decisions of strategic management.

4 Closing remarks

This paper aims to establish a theoretical framework of constructs that constitute corporate marketing: corporate identity, corporate image, and corporate reputation. These terms are often confused or used interchangeably; the reason for this is the existence and influence of other synonymous terms because an unambiguous terminology has yet to be universally accepted. This has made it all the more important to establish the area of each term and grasp the procedural course of theory development to understand what knowledge we have at our disposal today. Corporate identity is an individual characteristic by which an organization is recognized; it is the presentation of the organization from within its internal resources. Corporate identity is the starting point for building corporate image. An organization creates an image through its identity and how that identity is perceived by the general public. Within the framework of corporate marketing, stakeholders, who create their own picture of the organization, are at the center of attention. Corporate reputation, however, is an umbrella expression, encompassing the sum of effects of all external stakeholders, refined by the time-relate component and acquired experience.

Upon studying previous models, four conceptual models were selected that deal with the interrelationship of the constructs discussed. These are the models of Marwick and Fill (1997), Grey and Balmer (1998), Stuart (1999), and Chou (2005). By incorporating and explaining a growing number of terms and constructs, their models provide an insight into the growth and development of knowledge and new understanding resulting from new research in this field. Almost all models include communication within and outside the organization, while rarely does any model clearly separate and explain the difference between corporate image and corporate reputation. Seeing the need for outlining a new model that would be abreast of the latest advancements of the academic community in the field of coporate marketing, this paper proposes a new model that seeks to incorporate the previously excluded variables and is based on previous theoretical achievements. The new two-dimensional model plots stakeholders and time within a coordinate system, with communication being a vital factor in facilitating the corporate process. It vividly provides a graphic explanation of the mentioned constructs that derive their characteristics from their interrelationship with internal and external stakeholders and time. To ensure a clearer picture and linearity, the elements which make up the constructs have been intentionally omitted, as they would complicate the graphic presentation and make it harder to read. Challenges for future research include proving the credibility of this conceptual model using empirical instruments, expanding the model with new advancements in research as well as with the elements comprising the constructs, and applying the model in various sectors and in various research aims.

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Incident Management and Digital Evidence

Petr Doucek
University of Economics, Prague, Czech Republic
doucek@vse.cz

Lea Nedomová
University of Economics, Prague, Czech Republic
lea.nedomova@vse.cz

Jaromir Veber
University of Economics, Prague, Czech Republic
jaromir.veber2@vse.cz

Abstract

A boom of our society started a lot of years ago in the dark period of human's history. The same character has also a globalization process of the whole society that accelerated in the period of last ten years. Growing complexity of information systems and their permanently increasing role in support of decision-making process also started the new informatics boom several years ago. This speed in communication is a big challenge for those who - for some reason - need to keep reliable and provable information. These can be businesspersons, officials, attorneys, judges or investigators. As the value and quantity of stored digital data keep growing, so does the risk that someone will try to make such data unavailable, to steal them or to tamper with them. A large part of these incidents is currently illegal; however, their investigation and proving are usually not very successful. Moreover, there will always be incidents which are not punished by law yet disturb the running of an organization, and even these incidents must be investigated and possibly punished. In this article, we focus on the procedures in in-house investigations within an organization. It concerns mainly misdeeds that can be proven by forensic investigation. A thus defined area includes a relatively large number of misdeeds that may not be just of a "cybernetic" nature, but their traces are available in digital form and their consistent and correct analysis can provide necessary evidence proving such misdeeds. We also present a methodology – recommended procedures – that an organization should follow in order to obtain valid evidence from digital traces to prove incidents that violate the regulations of an organization. The investigation of different incidents can also be a part of an audit.

Keywords: Security Incidents, Digital Forensics Investigation, Digital Evidence, Legal Aspects

1 Introduction

Nowadays when implementation of modern complex information systems within the society brings with itself several special new aspects of its use and operation, is relatively increasing occurrence of the information system (IS) breaking on effective functionality. The increasing dependence on information technology (ICT) is visible on each step in our life – people are already communicating by social networks, corporations report about increasing share of "paperless" transactions, money transfer included, and the danger of collapsing of our society is higher and higher.

When all information technologies work correctly and all IS's functions are available on appropriate level of accessibility and confidence, is the situation optimal. But problems start when digital communication crashes or it is by intent damaged by external or internal subject – the digital incident appeared. Incident detection processes must be included into the general corporate architecture (Nedomová et al, 2014) and must be supported by appropriate knowledge and skills (Helfert et al, 2013; Rosický & Pavlíček, 2006). Then come to realization digital evidence processes especially processes focused on digital traces (potential digital evidence) to prove incidents that violate the regulations of an organization. The investigation of different incidents can also be a part of an audit (Svatá, 2012).

For starting the digital evidence processes, there is important to establish the "Security Incident Management Systems" (SIMS) in the organization. In order to start a successful investigation, it is necessary that an organization already have an SIMS in place (Forte, 2007; ISO/IEC 27035, 2011; Mitropoulos et al, 2006; Susanto et al, 2011). This requires two very important necessities without which the investigation cannot be started. The first, preparing step of SIMS is increasing the information security awareness. This process has permanent character and it is a part of readiness for information security. Details of it are presented for example in (ISO/IEC 27032, 2013), it improvement is discussed in (Doucek et al, 2011). The level of information security awareness determines the quality of information security incident system and its effectiveness and efficiency as well. The typical schema of information incident management system is presented on Figure 1.

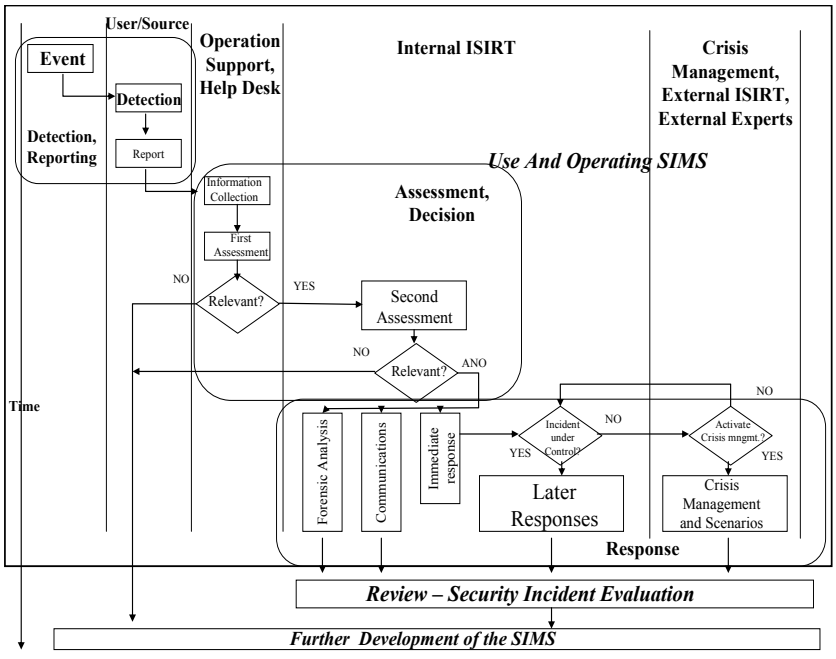

Figure 1: Schema of Security Incident Management (ISO/IEC 18044, 2004)

Processes are split on by following way:

- **User/source oriented process** included the Help Desk function, where the security awareness plays the key role,
- **Internal ISIRT (Information Security Incident Response Team) process –** is the core of in-house security incident process it; contents procedures for successfully response on incident in order to minimize its impacts.
- **Crisis management process -** External ISIRT obligations and information system crisis and scenarios management; this process stars when the organization is not able to solve the incident by its own sources and the incident turns to crisis,

The last collocated process is the evaluation of security incident and its evaluation. This process is important in applying the PDCA concept (Deming, 1982). Logic of their solutions is in general based on gradual improvement of information security management system. This is related to Deming's concept PDCA (Plan, Do, Check, Act). Application of PCDA concept to a model of incident security management enable firstly define and setup incident security system, then run it and on the base of feedback – by the Check phase – continuously improve the management system. (Doucek & Novotný, 2007).

2 Digital Evidence

After formalizing the incident management, it is time to start the next step – to design, to realize and to manage the digital evidence management system. This one is an interdisciplinary issue since provability and reliability are terms associated with law, i.e. the legal sector, while safety and information are terms associated with the IT industry. This issue is the subject-matter of the discipline called forensic investigation. Forensic investigation is a very fast growing branch that adjusts to all information technology trends, in particular to everything related to data processing and storing and the means of communication.

If we want to secure evidence in digital form, it is necessary to particularly observe the following principles (Ieong, 2006; ISO/IEC 27005, 2011):

- **Reliability** – all processes used in analyzing potential digital evidence must be repeatable and auditable; evidence must be obtained in a provable, possibly repeatable and certainly documented or auditable way from reliable media (e.g. disks verified by their owner, the police or an expert in this field).
- **Sufficiency** – qualified authorized persons (person), who conduct the initial securing of digital evidence, should take into consideration the size of an examined data sample in order to perform all activities necessary for requested findings; this includes information about the quantity of materials that they received for processing or, as the case may be, information about which material from which entity they requested and how this request was satisfied.
- **Relevance** – evidence must clearly correspond with the subject-matter of investigation and must be important for the investigation of an incident and there must be a good reason why evidence should be included in the investigation. Evidence must clearly confirm or disconfirm certain claims and may not allow more possibilities or interpretations.

The digital evidence system in an organization provides on the highest level the guidelines that encapsulate idealized models for common investigation processes across various

investigation scenarios (Veber & Klíma, 2014). It should includes processes from pre-incident preparation up to and including returning evidence for storage or dissemination as well as general advice and caveats on processes and appropriate identification, collection, acquisition, preservation, analysis, interpretation and presentation of evidence.

Its basic principles are:

- **Repeatability** is understood to mean that an investigator, who obtained certain evidence, should be able to reach such evidence repeatedly, using documented procedures. This principle is exceptionally important to any general investigation. Guidelines for many investigation processes have been provided to ensure that there is **clarity and transparency** in obtaining the produced result for each particular process. Established guidelines covering incident investigation principles and processes would expedite investigations, because they would provide a common order of the events that an investigation entails. Using established guidelines allows smooth transition from one event to another during an investigation. Such guidelines would also allow proper training of inexperienced investigators. The guidelines, furthermore, aim to ensure flexibility within an investigation due to the fact that many different types of digital investigations are possible. Harmonized incident investigation principles and processes are specified and indications are provided of how the investigation processes can be customized in different investigation scenarios.
- **Auditability** is understood to mean that the investigation procedures and results should be verifiable by any independent authorized party. For this reason, original data must always be available and must be recorded, and any procedure and method of data handling must be documented.
- **Justifiability** is understood to mean that an investigator should be able to defend his actions and procedures. To defend is understood to mean to prove that the selected procedures and methods are the best way to obtain all possible pieces of evidence.

Any digital investigation requires a high level of expertise. Those involved in the investigation should be competent, proficient in the processes used, and they should use validated processes (ISO/IEC DIS 27041, 2014) which are compatible with the relevant policies and/or laws in various jurisdictions.

2.1 Digital Evidence Processes

General scheme of the Digital Evidence Processes, based on international standard ISO/IEC 27043, is presented on following Figure 2.

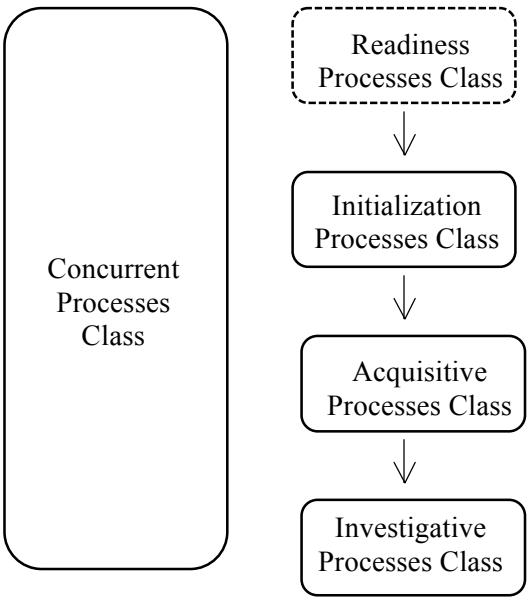

Figure 2: The Various Classes of Digital Investigation Procesess (ISO/IEC DIS 27043, 2014)

The six concurrent (Obtaining Authorization Process, Documentation Process, Managing Information Flow Processes, Preserving Chain of Custody Processes, Preserving Digital Evidence Processes and Interaction with physical Investigation Process) processes are aimed at allowing the said processes to be executed as on-going processes. The reason for having the concurrent processes is mainly to ensure more effective admissibility of digital evidence into a **legal system**, since, in the case of not having such processes, any investigation may run the risk that the admitted potential evidence might not be suitable for litigation due to improper handling, and documentation of potential digital evidence. These concurrent processes are, thus, based on principles that need to be followed throughout a digital investigation, alongside with the other classes of processes.

Readiness processes include that class of processes dealing with setting up an organization in such a way that, in the case that a digital investigation is required, such organization possesses the ability to maximize its potential to use digital evidence whilst minimizing the time and costs of an investigation. This class of processes is optional to the digital investigation processes. These processes are usually implemented for four main aims for digital investigation in organizations:

- to maximize the potential use of digital evidence,
- to minimize the costs of digital investigations incurred either directly onto the organization's system, or related to the system's services,
- to minimize interference with and prevent interruption of the or organization's business processes,
- to preserve or improve the current level of information security of systems within the organization.

These processes prepare standard model of digital investigation in an organization.
The **initialization processes class** consists of processes that initialize the digital investigation by handling the first response of an incident and planning as well as preparing for the remainder of the incident investigation process. The main processes are:

- incident detection process,
- first response process,
- planning process, and
- preparation process.

The **acquisitive processes** class consists of processes that are concerned with acquisition of potential digital evidence. The acquisitive processes, including the potential digital evidence are following:

- identification process,
- collection process,
- acquisition (if it is necessary; for in-house investigation is not usually applied),
- transportation process, and
- storage process.

The investigative processes class consists of processes that are concerned with investigating the incident that is the cause of the digital investigation and is concerned with analyzing the evidence, interpreting results from the analysis, reporting on results of the digital evidence

interpretation process and presenting these results in a court of law or to the relevant parties involved. Finally the digital investigation draws to a close within the investigation closure process. Following investigative processes are included in this class:

- potential digital evidence acquisition (if it is necessary; for in-house investigation is not usually applied),
- potential digital evidence examination and analysis process,
- digital evidence interpretation process,
- reporting process,
- presentation process, and
- investigation closure process.

2.2 Proposed Model

Based on above presented sources, we formulated the general model for in-house incident investigation. The first necessary step is to *recognize that an event (incident, misdeed)* and than follow establishing of regulations. If we are not able to recognize the incident or to distinguishe event and incident, we cannot start a successful investigation.

The second step is to have *sufficient recorded data* about the event/incident. If we know that the incident occurred, but we do not have a sufficient quantity of recorded data about such an event/incident, it will be difficult not only to identify the culprit but also to collect sufficient digital evidence to prove the investigated incident.

The conceptual incorporation of digital investigation during incident management is presented on Figure 3.

Until an incident is processed and is collected sufficient information about it, can we start an actual investigation and use the by us proposed methodology. Of course, all this applies if it is appropriate to investigate the incident and to try to identify the culprit and to prove his misdeed. Let's mention necessary interaction between team of people working on incident handling and team of people working on digital evidence collection tasks. These two tasks often represent conflicting actions - we want to resolve the incident as quickly as possible and at the same time we need to get as much information about it as possible. In order to satisfy both needs the teams should communicate and find the balanced way to collect enough evidence while resolving the incident as fast as possible.

However, before we start discussing the actual investigation, it is necessary to determine who will conduct the investigation, which depends on the seriousness of the misdeed. The misdeeds, which fall under the **crime category**, are punished pursuant to the Penal Code and very often result in a considerable damage (over 180 EURO for the Czech legel frame) or a grave bodily harm. Evidence concerning a crime is collected by the police and the crime must be proven in court by the investigating authority (expert witnesses or expert institutes). In such a case, an organization will only provide sufficient data and information to the police who will collect, process (analyze), store and interpret such data.

The misdeeds, which fall under the **civil dispute category**, are also resolved in court, but do not fall under the crime category (and for this reason they will not be investigated by the police). However, evidence used in court must be of legal value and for this reason, digital evidence must be prepared by a court expert. In such a case, if an organization wants to win the assumed civil dispute, it must hire a court expert experienced in digital investigation and provide him with sufficient data/information for obtaining sufficient evidence. The hired court expert is then responsible for investigation.

The last possibility is that a misdeed, **which does not fall under any of the previous categories but violates the in-house regulation of an organization**, and the organization management wishes to investigate it in order to find the culprit and prove his misdeed. In such a case, it is possible to use internal resources of the organization to investigate the entire matter. However, even in this case, an investigation should be conducted, using standard investigation methods. This is not only because it is necessary to prove the authenticity of obtained evidence to all parties involved, but also because there is a rather big risk that this misdeed will end up in court.

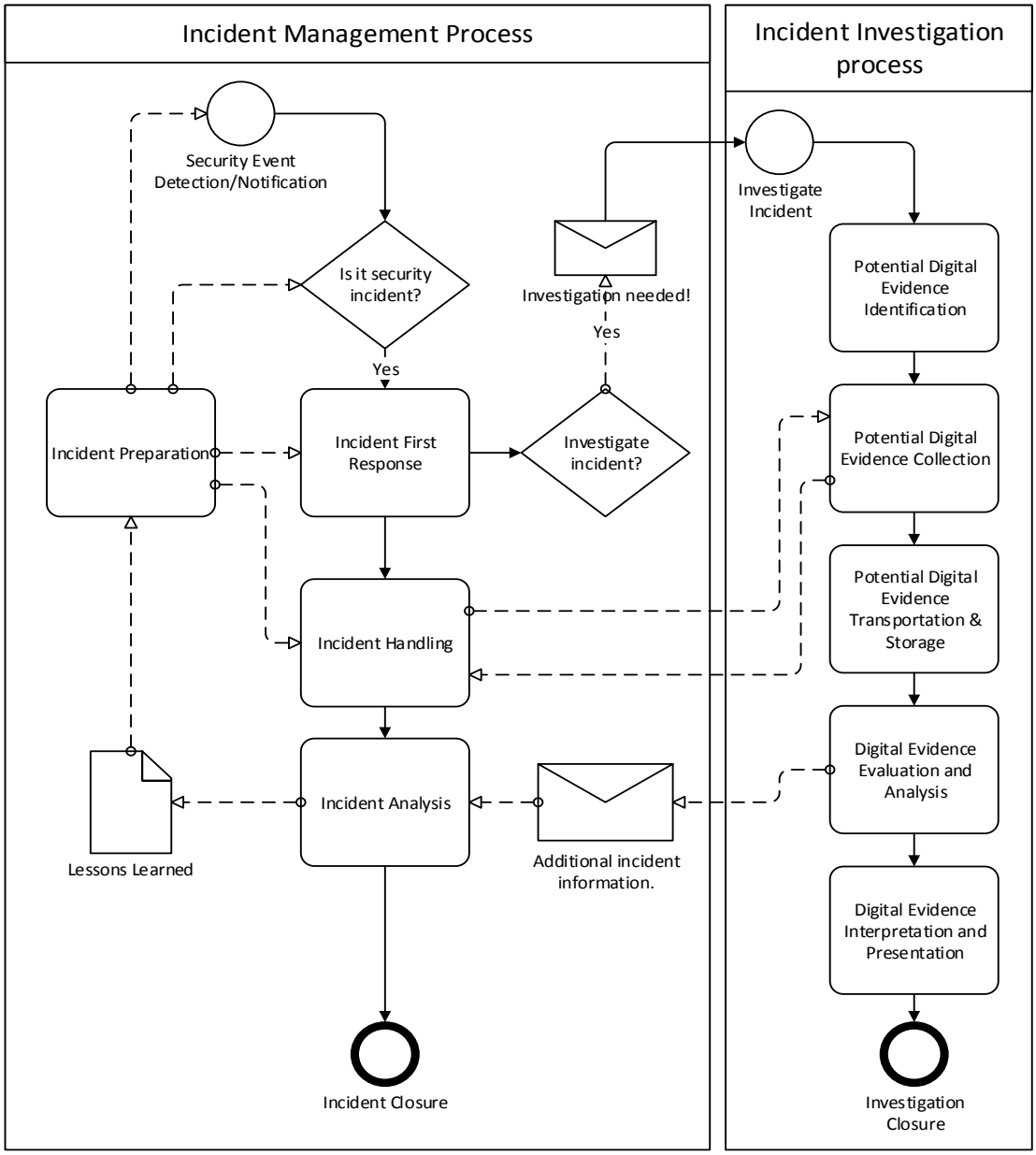

Figure 3: Overall Event Handling Scheme (Authors)

3 Conclusions

This contribution presents a simple framework that can be used in investigating misdeeds in an organization after a security event or incident. It is designated for public and state administration organizations as well as for the private sector. It is not designated for the investigating bodies of courts, experts or expert institutions. In view of the used legislation,

the proposed procedure is primarily designated for organizations in the Czech Republic and is based on the conceptual Figure 3. The model is currently being tested in Czech practice in cooperation with local and international companies.

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Designed Competency Model for Slovene Sign Language Interpreters

Darja Fišer
Association of Slovene Sign Language Interpreters, Slovenia
dfiser@siol.net

Gozdana Miglič
University of Maribor, Faculty of Organizational Sciences, Slovenia
gozdana.miglic@fov.uni-mb.si

Abstract

The article is related to the designed competency model for Slovene sign language interpreters. For preparing the preposition of competency model three researches were made: international research collecting data in 35 European and 15 non-European countries, research in Slovenia analyzing the existing situation among Slovene sign language interpreters and research in Slovenia establishing the proposal of competency model where four groups of participants were included: Slovene sign language interpreters, deaf users of the interpreting service from Slovene spoken language to Slovene sign language, hearing users of the interpreting service from Slovene sign language to Slovene spoken language and representatives of public institution who are also users of the interpreting service from Slovene sign language to Slovene spoken language. The article presents four groups of competencies and single sub-competencies designed into a model. However, several key questions still remain unanswered: setting the quality standards for interpreters' work, standardization of Slovene sign language and the establishment of an education system for interpreters. The proposed competency model represents the starting point for establishing these systems in Slovenia.

Keywords: Competency Model, Slovene Sign Language Interpreters

Povzetek

Članek je povezan z oblikovanim modelom kompetenc za tolmače slovenskega znakovnega jezika. V okviru priprave predloga modela kompetenc so bile opravljene tri raziskave: mednarodna raziskava z zbiranjem podatkov v 35 evropskih in 15 neevropskih državah, raziskava v Sloveniji z analizo obstoječega stanja med tolmači slovenskega znakovnega jezika ter raziskava v Sloveniji za vzpostavitev predloga modela kompetenc, kjer so bile vključene štiri skupine udeležencev: tolmači slovenskega znakovnega jezika, gluhi uporabniki storitve tolmačenja iz besednega slovenskega jezika v slovenski znakovni jezik, slišeči uporabniki storitve tolmačenja iz slovenskega znakovnega jezika v besedni slovenski jezik ter predstavniki javnih institucij, ki so prav tako uporabniki storitve tolmačenja iz slovenskega znakovnega jezika v besedni slovenski jezik. Predstavljeni so štirje sklopi kompetenc in

posamezne kompetence, ki so oblikovani v model. Še nekaj ključnih vprašanj ostaja odprtih: standardi kakovosti dela tolmačev slovenskega znakovnega jezika, standardizacija znakovnega jezika, vzpostavitev izobraževalnega sistema za tolmače. Predlagani model kompetenc predstavlja izhodišče za vzpostavitev teh sistemov v Sloveniji.

Ključne besede: model kompetenc, tolmači slovenskega znakovnega jezika

1 Introductory Platform

1.1 Baseline Thesis

With the Act on the Use of Slovene Sign Language – AUSSL (Official Gazette RS, No. 96/2002) adopted in 2002, Slovene sign language (SSL) was recognized as the official language of the deaf. Following the adoption of the Act, the Association of Slovene Sign Language Interpreters and the Council for Slovene Sign Language were established and internal rules, which provide the current basis for the interpreters' work, were adopted (Fišer et al., 2014).

The Association is responsible for implementing the provisions from the Act in every institution. Additionally, there are more issues opened related to Slovene Sign Language interpreters (SSLI), which are:

1. there is no competency model for SSLI and therefore open issues are also:
    a. there are no quality standards for the work of SSLI,
    b. there is no adequate system of education, neither for future SSLI nor for permanent education of SSLI,
    c. there is no control over the performance of services and the competency of SSLI,
    d. there is no standardization of SSL.

The main thesis is building the Competency Model for Slovene Sign Language interpreters.

The actual arrangement of the work of SSLI in Slovenia, besides AUSSL, is determined by two internal acts; *Code of Ethics for Slovene Sign Language Interpreters* (1994) which presents the basis for the work of SSLI, and *The Rules of Discipline of Slovenian Sign Language Interpreters* (2006) which provides sanctions for the violation of the Code.

The main guidelines of our work were (Fišer et al., 2012):

- Increasing the demand for interpreting service. An increased awareness of the deaf will require more interpreting service in the future. This may result in several problems because of the decentralized system for the work of interpreters. We assume that there will be a higher demand for the continuous education of SSLI which is momentarily left to each individual and is not addressed by any mechanism.
- Progress in society; the development of the Slovene language already requires the development of SSL, because there are no new signs and additionally it is highly important to have a unique understanding of all current signs.
- Currently there are almost no limitations for the work of SSLI which is mainly due to ill-defined laws, regulations and internal acts. Therefore, gaps and loopholes arise which are understood by individual interpreters and exploited in their own manner at the expense of reputation, professionalism and the quality of SSLI work. In several segments, some come to abuse the system.

- Increased demand for interpreting service from day to day demands more interpreters to increase the coverage across the country. So it will be necessary in the near future to establish an education system for future interpretation to be carried out at a higher level. The basis for this will be a competency model, supplemented by quality standards of work.
- Development in this field will require (some segments already require) the establishment of an institution.

1.2 Slovene Sign Language Interpreters

The 4th paragraph of AUSSL defines SSLI as a person who interprets Slovene spoken language into Sign Language for deaf persons and Sign Language into Slovene spoken language for hearing persons. The interpreter must be an adult, have a certificate in accordance with regulations which must be approved as national professional qualification, and the interpreter/he or she has to be listed in the register of the interpreters. Interpreters are committed to the Code of professional ethics in their work (Fišer et al., 2014).

The first interpreters were the children of deaf parents who were pushed into taking two roles – the role of a child and the role of an interpreter. To many of them, their parents' deafness represents some sort of a deficit in their basic education. When the need of deaf people to communicate with the hearing world started to increase (mainly after the adoption of AUSSL), a greater need for interpreters arose. Consequently, the first teachers of SSLI were also the children of deaf parents whose mother tongue was Sign Language (Bauman, 2009).

The first interpreters in Slovenia received certificates in accordance with the National Professional Qualifications Act as professional Slovene Sign Language interpreters in the year 2004 (Catalogue of Professional Knowledge and Skills, 2001). They didn't obtain formal education but rather only completed courses, preparatory programs and gained work experience.

Currently, the regulation of the education system for Sign Language interpreters in Slovenia represents starting and advanced Sign Language courses organized by various institutions. The Association of Slovene Sign Language Interpreters is the operator of the preparatory program for preparing participants for certification as future Slovene Sign Language interpreters in accordance with the national professional qualifications. Regarding the process of certification, anybody with previous knowledge of SSL can be registered (Fišer et al., 2013).

The field of SSL interpreting service and the work of SSLI in Slovenia is unsystematically arranged, unfinished and incomplete in several fields. On 31st December 2014 there were 46 certificated SSLI in Slovenia who are registered at the Ministry for Work, Family and Social Affairs.

1.3 Practice Abroad in the Field of Sign Language Interpreting

In practice, most European countries are governed by an operational code of ethics, some also have professional occupational standards as well as a regulator in several areas where interpreters are needed the most and where the system of Sign Language interpreting is developed, for example interpreting during the education of deaf students and education for interpreters (Napier, 2009). A research in 50 countries in the world has shown that competency models in this form are not set anywhere. They have set the competency model and quality standards for the work of Sign Language Interpreters mostly in their Code of Ethics, Code of Conduct, but not especially as competency models.

The research included 35 European and 15 non-European countries, altogether 50 countries. European participant countries were: Albania, Austria, Belgium / Flanders, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, England, Wales, Northern Ireland, Scotland, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Iceland, Kosovo, Lithuania, Latvia, Malta, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovenia, Spain, Sweden, Switzerland, the Netherlands, and Ukraine. Non-European participant countries were: Arab countries, Argentina, Australia, Brazil, Canada, India, Israel, Japan, South Africa, Kenya, Madagascar, New Zealand, Tanzania, Zambia, and USA.

The research aroused interest that the designed competency model would also be applied in the participant countries as it presents the main document from which other mechanisms that are not used in many countries can originate.

The following paragraphs summarize research findings in the field of *competencies*. European countries are not familiar with competencies in a form of a model but have them presented or gathered in various forms. Competencies are mostly structured in a form of ethical codes (Norway, Poland, the Netherlands), within work quality standards (Belgium / Flanders, England, Wales and Northern Ireland, Estonia), in education programs (France, Ireland, Spain). In Scotland, the competencies are written in a register where qualifications of SL interpreters are checked.

The results gathered in the non-European participant countries do not vary much from the results in the European countries. There is no competency model in use and competencies of SL interpreters are written in ethical codes (Australia, Canada). Similar to Scotland, USA use a certification system to classify competencies. In Japan, competencies are defined within the examination system after finishing education and obtaining qualification.

1.4 Current Situation in Slovenia

A preliminary research in 2010 among 41 interpreters has shown that there is a great need for a competency model for SSLI and for work quality standards for SSLI. Interpreters need to be familiar with different fields of work, whether this is the first contact with users and/or institution or just preparation for a task, its realization and personal appearance. Consequently, the need to standardize SSL, i.e. to unify and develop new gestures, and the need to unify the education system for interpreters arose, focusing on permanent education for certified interpreters.

According to interpreters, the competency model for SSLI and work quality standards for SSLI could be defined as standardization unifying work and mainly eliminating the diversity of current practices. The research also stresses that the education system needs to be established on the basis of the competency model for interpreters with a strong emphasis on the quality of work.

The competency model for interpreters and work quality standards would therefore result in a higher quality of work, greater professionalization of the occupation, greater uniformity throughout the country, and nevertheless personal development of an individual. The competency model would provide an overview of the current situation in the field, possibility of upgrading the interpreters' work, and increased awareness of the occupation. The advantage would therefore be a more qualitative work, greater professionalization of the occupation and at the same time this would be an opportunity for an improved manner and higher quality of work. On the other hand, the results of the research show the disadvantage of standards that would result in additional workload for an interpreter and the hazard of standards due to a higher demand for interpreters.

2 Competency Model for Slovene Sign Language Interpreters

On the basis of the research on systems across Europe and abroad (Fišer, 2011) a good competency model for SSLI can be established, which can also be introduced around the world in those countries that still don't/do not have an established system. It is necessary to consider the specificities of the country, the population of the deaf and their needs and, of course, the legal settings.

2.1 Development of the Competency Model for Slovene Sign Language Interpreters

The competency model research in Slovenia was carried out in the period from late 2013 up to first moths in 2014. The research included 321 persons. It considered all participants who occur in the interpreting service from Slovene spoken language to Slovene sign language and vice versa, and who were included into the competency model:

SSL Interpreters No.=37 (the total number of interpreters on December 31st 2013 was 46; returned 80.43% of questionnaires). 21 interpreters already took part in a pilot research in which the questionnaire was tested. The first restriction in the research was the cooperation of SSL interpreters, but it was successfully overcome, since 80.43% of SSL interpreters took part in the research.

Deaf users No.=152 (919 deaf persons have the right to SSL interpreter according to AUSSL; 16.53% of questionnaires applying to the total number of the deaf with the right to SSL interpreter returned on December 31st 2013). The second restriction which extended the research was the cooperation of the deaf. In the first stage, the questionnaire was sent to associations for the deaf and hard of hearing throughout Slovenia – 5 questionnaires were returned. After checking the situation, the associations explained that the deaf do not understand the questionnaire, that they do not have time, that they do not have the possibility to do this extra work etc. The research was undertaken only after we visited the associations. 16.53% is the reflection of the personal contact and individual approach.

Hearing users who are not in direct contact with the deaf No.=55 (60 questionnaires were sent to random hearing persons by e-mail; returned 91.7% of questionnaires).

Public institutions No.=77 (150 questionnaires were sent to public institutions by e-mail; returned 51.3% of questionnaires). The questionnaire was sent to public institutions such as social work centers, retirement homes, town halls, administrative units, employment services, health centers, police, cultural institutions, schools – all connected by the obligation of providing SSL interpreters when deaf persons are a part of a procedure and want to assert their right. It was important to get opinion from individual public institutions, from people employed in these institutions who have contact with the deaf users. They also form an opinion about the competencies of SSL interpreter who they work with.

All four groups of interviewees stressed knowledge (4.79) as the main and the most important competency. It got the highest evaluation from the hearing participants (4.90), interpreters (4.79) and interviewees from public institutions (4.76) followed. The deaf evaluated the competency of knowledge as important (4.68).

The competency of responsibility ranked second (4.55). It got the highest evaluation from the hearing participants (4.81) and the lowest from the interviewees from public institutions (4.29). The competency of cooperation was ranked third by interpreters (4.68) and the deaf (4.42).

The competency of cooperation was ranked third only by a millisecond (4.54). It got the highest evaluation from interpreters (4.77), hearing participants (4.75), and the deaf (4.50). The lowest evaluation was given by the interviewees from public institutions (4.14) which makes it the lowest ranked competency.

The lowest ranked competency by all participants was the competency of development. It was ranked highest by the hearing participants (4.71), lower by interpreters (4.46) and interviewees from public institutions (4.24), and the lowest by the deaf (4.22).

There are no bigger deviations in evaluation of the competencies among groups of participants. This was also proven by the matrix analysis made by four experts (Figure 1).

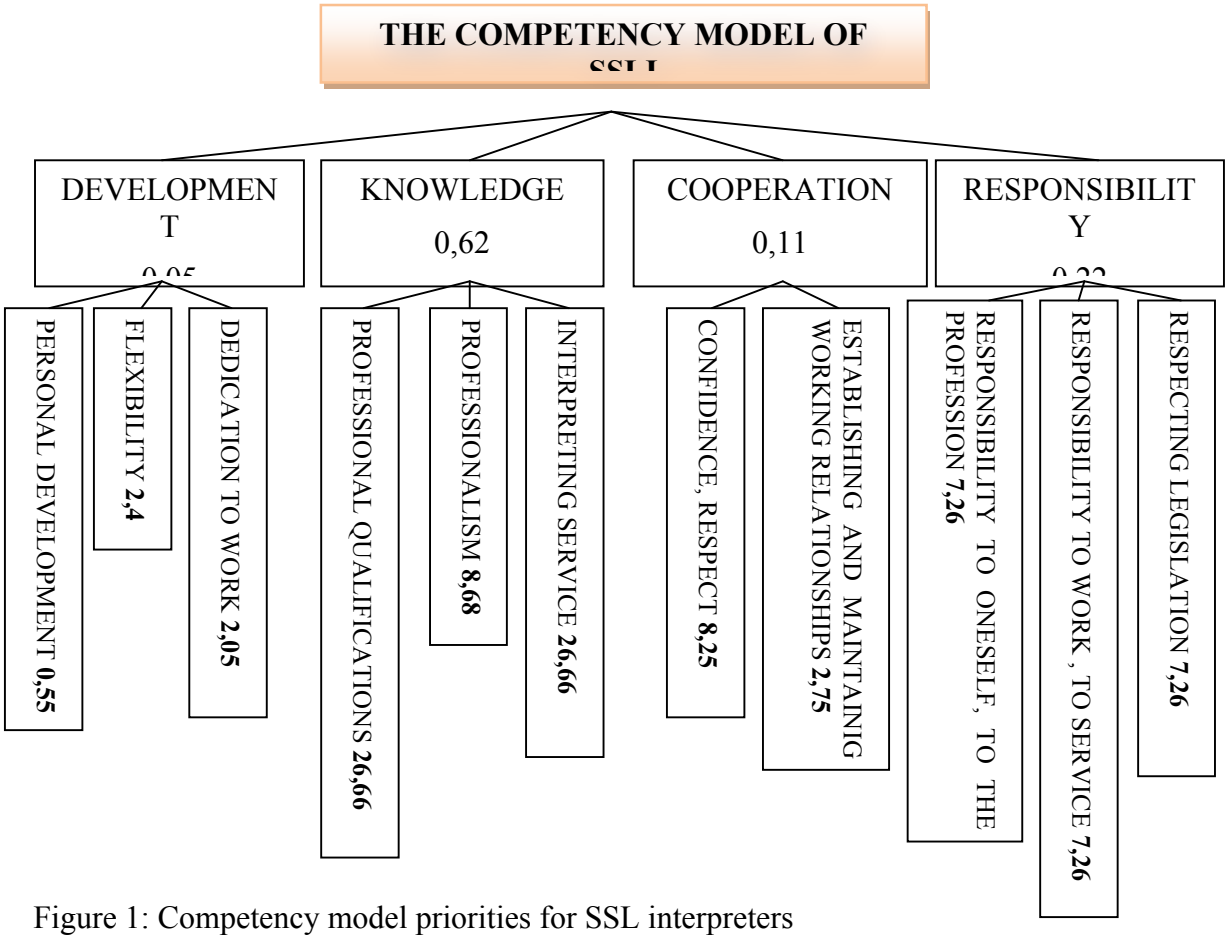

Figure 1: Competency model priorities for SSL interpreters

This is how the priority of individual competencies for SSL interpreters was set; it is presented in Figure 2.

Competency code	Competency description	INTERPRETERS	THE DEAF	THE HEARING	PUBLIC INSTITUTIONS	OVERALL EVALUATION	COMPETENCY IMPORTANCE
1	DEVELOPMENT	4,46	4,22	4,71	4,24	4,41	4
1.1	PERSONAL DEVELOPMENT	4,22	4,08	4,43	4,03	4,19	
1.2	FLEXIBILITY	4,51	4,20	4,77	4,24	4,43	
1.3	DEDICATION TO WORK	4,65	4,39	4,92	4,46	4,61	
2	KNOWLEDGE	4,79	4,68	4,90	4,76	4,79	1
2.1	PROFESSIONAL QUALIFICATIONS	4,81	4,66	4,94	4,81	4,81	
2.2	PROFESSIONALISM	4,75	4,68	4,88	4,71	4,76	
2.3	INTERPRETING SERVICE	4,81	4,71	4,89	4,77	4,80	
3	COOPERATION	4,77	4,50	4,75	4,14	4,54	3
3.1	CONFIDENCE,	4,85	4,77	4,92	4,41	4,74	

	RESPECT						
3.2	**ESTABLISHING AND MAINTAINIG WORKING RELATIONSHIPS**	**4,69**	**4,22**	**4,57**	**3,87**	**4,34**	
4	**RESPONSIBILITY**	**4,68**	**4,42**	**4,81**	**4,29**	**4,55**	**2**
4.1	**RESPONSIBILITY TO ONESELF, TO THE PROFESSION**	**4,57**	**4,31**	**4,79**	**4,15**	**4,46**	
4.2	**RESPONSIBILITY TO WORK , TO SERVICE**	**4,69**	**4,28**	**4,81**	**4,24**	**4,51**	
4.3	**RESPECTING LEGISLATION**	**4,77**	**4,66**	**4,83**	**4,49**	**4,69**	

Figure 2: Comparative evaluation of the competencies among interpreters, the deaf, the hearing, and public institutions

The competency model for interpreters is based on four main competencies combining individual competencies in strands (Figure 3).

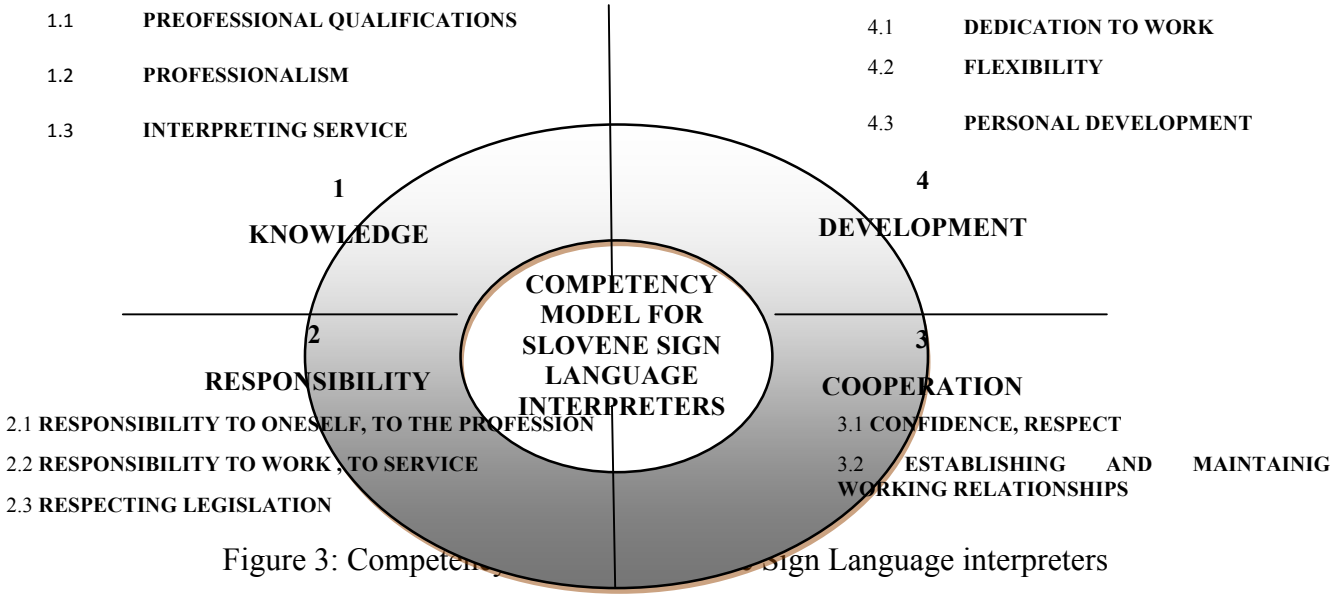

Figure 3: Competen[illegible] Sign Language interpreters

The competency model includes four strands that include individual competencies:

1. *Knowledge*

- *Professional qualifications* of SSL interpreter represent his/her initiative, principle, ability to think logically, critical analysis and problem solving, independence in work. This person has language, socio-linguistic, speaking, gesture competencies and masters pubic performance. He/she has no stage fright, knows how to behave in front of the audience, expresses himself/herself understandably and clearly, is able to listen and hear, is communicative, successfully manages conflict situations, follows speaker's purpose and gist, identifies relation and tone expressed verbally or non-verbally, establishes ongoing dialog among users, is familiar with interpreting and social protection legislation, information technologies and deafness, has the required level of education and continues to permanently educate himself/herself by gaining new knowledge and studying literature from various interpreting areas, learns new strategies for personal growth, takes part in seminars, courses, and uses broad global knowledge. He/she is in good medical condition and fit due to special work conditions, takes care of his/her physical and mental health, relaxes, has the ability to be a mentor, can critically evaluate, is impartial, is able to observe and perceive, has a good memory, can read gestures precisely, is concentrated, is able to interact, masters communication strategies, predicts outcomes and problems in the interpreting service, masters SSL dialectal features, connects academic and global knowledge, understands the content, finds common thread of the information, is aware of his/her professional competence, estimates the complexity level of interpreting, has knowledge, skills, and ability to master the following areas: education, health care, judiciary and law, social protection, technology, economy, sports, leisure, linguistics, sociology, natural sciences, public service and public administration, conference interpreting, personal life, interpreting for different groups of users (the deaf, the deaf youth, the deaf-blind, the deaf elderly etc.). He/she is familiar with the deaf community, their cultural context, user's social network, and organizations in the field of deafness. He/she respects cultural diversity, individuals and systems of people of other cultures, classes, races, ethnic groups, religious groups etc. He/she is culturally and interculturally sensitive.
- *Interpreting service* and its mastery concerns competencies that enable an interpreter to choose techniques and types of interpreting. The interpreter has knowledge of linguistic and intercultural theories of interpreting in different contexts, connects knowledge, experiences, skills, and work, provides healthy working environment, creates an appropriate communication connection between users, asks for feedback in order to understand the information, adjusts ways of interpreting to user's level of understanding, interprets facts, concepts, opinions, purpose, relations and feelings, paraphrases, gently interrupts the speaker for explanation and for checking the meaning, is inventive in case of interruptions, uses gestures correctly, gives comprehensive and exact information, connects contents, forms clear and understandable texts in spoken and sign language, corrects information up to a point when they are understood clearly, interprets precisely, adequately and quickly, making sure the information is reliable, thoroughly transfers the meaning of the original text, allows improvement of interpreting, does not abandon work, has access to transferred information, identifies meaning and importance of the information and confirms its credibility. Moreover, he/she makes sure that the material conditions are good, that there are enough tools for the working process, he/she also chooses the right clothing that is in accordance with the code, i.e. in contrast with hands, he/she does not wear

jewelry, does not use too much make-up, and gives up on everything that could divert attention during the process of interpreting. He/she protects the workplace and himself/herself, acts in accordance with the code, controls the area and the working conditions, plans, keeps record of work, manages different processes, organizes work, masters the process of hiring an interpreter, can encipher and classify orders, prepares for the service, uses relevant information sources for the task preparation, makes his/her own glossaries, collects terminology, investigates, acquires relevant material before the interpreting service, carries out and manages the whole interpreting service, reports, evaluates work, rejects a task in case of incompetence, provides feedback, meets deadlines, dates, and promotes the interpreting service.

- *Professionalism* is a competency that refers to integrity, persistence, objectivity, impartiality, assertiveness when enjoying rights and carrying out obligations, creativity. The interpreter tries, in a subtle manner, to raise awareness among users (the deaf and the hearing) about the importance of the right to an interpreter and interpreting service, objectively estimates users' competencies, is an interpreter and not an advocate, knows interpreter's role, considers communication effect, assesses the language in use according to language rules, is familiar with interpreter's rights and obligations, raises general public awareness, self-evaluates, understands qualifications based on the competency model, respects the rule of secrecy, accepts constructive criticism and rejects destructive criticism, has the ability to empathize, is emotionally and personally stable, does not manipulate the users and the hearing, takes care of his/her reputation and the reputation of the occupation, is professional, makes appropriate decisions, expresses satisfaction with the accomplished work, ensures that user's needs are satisfied, takes care of wider self-awareness and discretion, is correct, promotes individuality, and intervenes in order to clarify the information. He/she also gathers and shares information with great proficiency and flexibility in spoken or written language in various situations among different speakers, is able to differentiate between personal and work-related problems, shares experiences with other interpreters, analyses advantages and disadvantages of his/her work, and seeks appropriate help in specific situations.

2. *Responsibility*

- *Respecting legislation* is a competency that accustoms SSL interpreter to respect rules and norms written in documents (Code of Ethical Principles in Social Protection, Code of Professional Ethics for Interpreters). He/she makes payment at the tariff for the accomplished work, respects internal acts of the association, works in accordance with the requirements, treats everyone equally and equivalently, behaves ethically, is neutral, is excluded from the procedure in cases under the code, makes decisions based on facts and in accordance with the code.
- *Responsibility to work, to interpreting service* combines competencies of professional behavior, making sure that the interpreter provides interpreting service with full responsibility, never placing it on others. He/she leaves other responsibilities to users and doesn't do their work, is responsible for violations of duty, honors agreements, and turns down a task if it involves unethical practices.
- *Responsibility to oneself, to the profession* includes personal competencies of SSL interpreter. This means he/she is responsible to himself/herself and to his/her work, is aware of the interpreter's role, always tries to retain professional integrity, and raises profession's perception and reputation by providing quality service.

3. *Cooperation*

- *Confidence and respect* is a collection of competencies fundamental for cooperation. SSL interpreter is respectful of the surrounding world, respects the user, his/her profession and the service he/she provides, is trustworthy, maintains trust, respects SSL and language norms.
- *Establishing and maintaining working relationships* represents relationship competencies which means that the interpreter is tolerant when establishing a relationship, constructive, ready to cooperate. He/she connects users and has appropriate interaction with them, has a high level of understanding relationships, dynamics, interaction among users, is familiar with users' rights and obligations, has an appropriate and professional approach, knows how to establish an appropriate relationship with people he/she works with in the interpreting process, is a full-time interpreter and always uses SSL in order not to exclude or allow empowerment of users, fulfills or even exceeds user demands and expectations, keeps and maintains professional distance from users, cooperates in managing social consequences of deafness, and cooperates with the environment.

4. *Development*

- *Dedication to work* includes competencies of motivation and dedication to lifelong learning and self-criticism.
- *Flexibility* combines adaptability competencies, personal adjustment to changes, adjustment to relationship changes, recognizing human behavior in socio-cultural context, adjustment to changed circumstances during a task.
- *Personal development* has to allow the possibility of development, so that the interpreter can evolve in every field, also personally, enabling him/her to be better and better.

3 Conclusions

AUSSL from 2002, adopting SSL as the official language of the deaf in Slovenia, opened the way for SSL interpreters and interpreting service, and demanded system establishment on every level. There were no basics in the competency model and the area was poorly systematically organized. Establishing the competency model formed a basis for other mechanisms (quality standards, education system, standardization, central institution). The competency model was designed anew, since a comparable model could not be found in Slovenia as well as in other countries, as the research has proven. Three researches were carried out in order to investigate similar models abroad and two researches in Slovenia which included relevant and representative participants: Slovenian Sign Language interpreters, deaf users, hearing users, and representatives of public institutions. A questionnaire was used to rank the four components (knowledge, responsibility, cooperation, and development), all of which also have a subcomponent. The four components rank in terms of importance and they were also verified by experts' analysis.

The competency model is simple, aggregated, and most importantly practical for using in Slovenia. With some adaptations it could also be used internationally. There has already been some positive feedback on the competency model which already became the basis for changing the professional code of SSL interpreters. On the other hand, there is also a negative side of the model, i.e. fear of change in every area of SSL interpreters' work.

The competency model is of vital importance and a priceless contribution to raising awareness of the field in Slovenia. It will not only contribute to a better understanding of processes, but

also to a better attitude towards the interpreting service and SSL interpreters – from the users' point of view as well as from other interested public members.

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Modelling and Control Automated Guided Vehicle Traffic at a Container Terminal

Anita Gudelj
University of Split, Faculty of Maritime Studies, Croatia
anita@pfst.hr

Maja Krčum
University of Split, Faculty of Maritime Studies, Croatia
mkrcum@pfst.hr

Mirko Čorić
University of Split, Faculty of Maritime Studies, Croatia
mcoric@pfst.hr

Abstract

Container terminal logistics has been a prominent field of research and the term Automated Guided Vehicle Systems has become a keyword in publications. This paper is devoted to the modelling and control of automatic guided vehicles (AGVs) assuming that the transportation system configuration is given as well as transportation task. AGVs follow a guide-path while controlled by a computer that assigns route, tasks, velocity, etc. The AGV motion can be described as the set of discrete events and states. Some of these states can be undesirable such as deadlocks and collisions. By applying adequate control policy to avoid such states and block the vehicles' motion only in the case of dangerous situation it is able to improve the container terminal's overall logistic efficiency. The Coloured Petri net is used for the process control specification.

Keywords: container logistics, container terminal, automated guided vehicles, coloured Petri net

1 Introduction

The volume of goods transported by containers through sea ports has been rapidly increasing during the last decade. The crucial terminal management problem is optimizing the balance between the shipowners who request quick service of their ships and economical use of allocated resources. To satisfy customer demand, it is paramount that ships are unloaded and loaded promptly at the port. The above consideration necessitates the implementation advanced technologies and development of highly sophisticated container transportation systems, which accommodate the increasing number of container ships and efficient movement within the container terminal. So, automated guided vehicles (AGVs) have become important transportation means in container transhipment systems (CTS) in order to increase the productivity and efficiency as well as to decrease the cost of container terminals. There

AGV systems represent subsystems consisting of vehicles providing the transport of containers among cranes, processing centres, measuring devices, buffers and storages.

Container terminal logistics has been a prominent field of research and the term Automated Guided Vehicle Systems has become a keyword in publications A comprehensive literature survey has recently been given by Steenken, *et al.* (2004). Further overviews have been provided in (Vis, 2006, Gudelj, 2010). The papers of Vis & Bakker (2008) and Steenken (2004) provide an excellent overview of the research of AGVs. The transport system performance combined with the production job scheduling determines the overall efficiency of CTS (Böse1, 2002, Gudelj, 2012).

The container transhipment systems (CTS) can generally be described as a discrete event system (DES) (Gudelj, 2012) which consists of discrete states and events. Some of these states, such as conflicts and deadlocks, are undesirable (even dangerous). These events and states are normally observed by the container terminal management system (CTMS). In this view, CMTS should implement supervisory policy which has to ensure that the process does not get into any of forbidden states (AGV collision or deadlock of vehicles) and that it performs in accordance with the given requirements.

Discrete event systems are growing in popularity and complexity. This is motivating us to use well organized methodologies to avoid failures and to optimize performance. In this paper, the main goal is to achieve conflict and deadlock free transhipment of containers within the terminal area. Coloured Petri net theory is used for modelling CTS and designing appropriate supervisor. Moreover, we modelled the AGV traffic lights by Timed Coloured Petri Net.

2 Background

2.1 Traffic control strategy of AGV system

The term automated container terminal will be used to indicate container terminals in which manual labour has been replaced by computer controlled equipment to handle containers, such as automated vehicles. In general, an AGV is a driverless transport system used for horizontal movement of materials. AGVs are especially used for the internal and external transport of materials. An AGV is a mobile robot that follows markers or wires in the floor. The AGVs were traditionally employed in manufacturing systems, but have recently extended their popularity to many other industrial applications, such as goods transportation in warehouses and container transhipment systems at container terminals.

The movement of AGVs usually takes place by following a set of predetermined, physical or virtual guide paths which are embedded in the facility layout. AGV has a lot of sensors which transmit data about it position to a central microcomputer. Control system takes this data and decides whether the AGV is moved or not, controls container transhipments, directs AGVs… Thus, in every time instance, it is known AGV's position, its speed and traffic conditions in specific zone.

AGV's have a set path on which they drive a predetermined direction and usually forms a circular loop. Proper traffic control is needed to avoid deadlock between a group of AGVs. The control strategy of the AGV system, which is presented in this work, uses the zone control approach. It is assumed that the tracks are divided into zones and the traffic is controlled by zones. These zones are specified as areas with a certain width and length and should be large enough to accommodate the entire body of a vehicle. The move of an AGV is controlled with a capacity of individual zone. In consider CTS system zone's capacity is

determined with a number of AGVs allowed to enter a zone. To achieve a primary goal of the AGV system – a collision free transport operation, we assumed that only a single vehicle is allowed to enter a zone.

For example, a deadlock situation will occur if the next zone in the planned movement of all the AGVs of a certain group is blocked by another AGV, which is also part of that same group (Image 1).

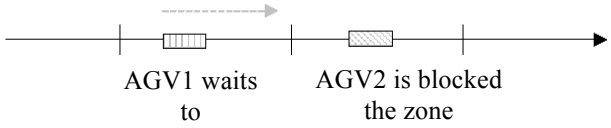

Image 1: The example of the zones in the planned movement of the AGVs

An elementary module for the AGV transportation class under study is depicted in Image 2. It is assumed that a complete transportation system is built up of two basic elementary modules: a zone and a crossing (or switch). Z1, Z2 and Z3 are zones in form of a straight or a curve line. It is allowed that only one AGV to be present in a single zone. As to control AGV position, the ends of the each zone are equipped with sensors. As it is depicted in Image 2 where the sensors are denoted as S_{ia}, S_{ib} (i=1, 2, 3). The sensors are located in safe positions dia, dib (i=1, 2, 3…) from the zone ends with respect to the known length of vehicles. The second building module is a switch in the form of single track branching as it is depicted in Image 2 where the switch is denoted as SWi. Physically, a switch is a junction that connects multiple lines. Each switch is associated with a set of ingoing lanes and a set of outgoing lanes. An ingoing lane of a switch allows an AGV to move towards the switch. Moreover, an outgoing lane of a switch allows an AGV to move away from the switch. No AGV stopping is permitted in the switching areas and it is allowed that only one AGV to be present in the switch. Generally bi-directional movements of the AGV in a switch are assumed, while it is restricted to uni-directional AGV movement for a zone.

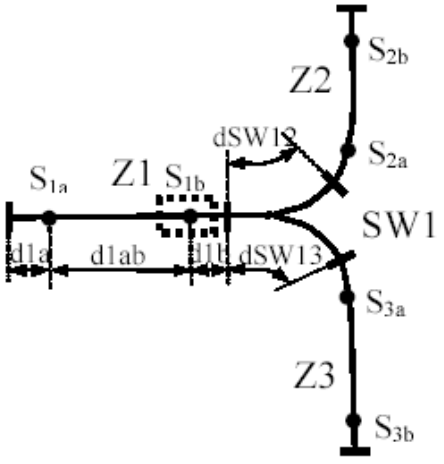

Image 2: The basic modules of AGV transportation system (Hrúz , 2007)

2.2 Timed coloured Petri nets

A coloured Petri net (CPN) extends the formalism of the Petri net by equipping each token with an attached value called the token colour. A CPN allows for a more compact representation of a behaviourally equivalent PN. Timed CPN extends the CPN formalism with the concept of time. This will allow us to evaluate how efficiently a system performs its operations and it also allows us to model and validate real-time systems.

The formal definition of the CPN as given in (Jensen, 1997, Ribarić, 2005) uses an expression representation and therefore presupposes that certain syntax exists together with a well-defined semantics.

A timed coloured Petri net (TCPN) is defined as a bipartite directed graph represented by a ten-tuple $CPN=(P,T,A,\sum,N,C,G,E,FT,\mathbf{m_0})$, where

- P is a set of places, T is a set of transitions, A is a finite set of arcs such that $P\cap T=P\cap A=T\cap A=\emptyset$
- $\sum$ is a finite set of non-empty types, called colour sets
- $N:A\rightarrow(P\times T)\cup(T\times P)$ is a node function which connects places to transitions and vice versa
- $C:P\rightarrow\sum$ is a colour function that associates with each element in P∪T
- G : T → [expr] is a guard function defined from T into expressions such that $\forall t\in T$: [Type(G(t)) = B ∧ Type(Var(G(t))) ⊆ ∑], B is Bool type
- $E : A \rightarrow [expr]$ is a logical arc expression function such that $\forall a\in A:[Type(E(a))=C(p(a))_{MS} \wedge Type(Var(E(a)))\subseteq\Sigma]$, where $p:A\rightarrow P$ maps each arc a to the component of $N(a)$ which is a place
- FT is a timing vector
- $\mathbf{m_0}$ is initial marking.

C maps each place $p_i\in P$ to the set of possible token colours $C(p_i)=\{a_{i,1},a_{i,2},\ldots a_{i,u_i}\}\subseteq\Sigma$, where $u_i=|C(p_i)|$ is the number of possible colours of tokens in p_i. Analogously, C maps each transition $t_j\in T$ to the set of possible occurrence colours $C(t_j)=\{b_{j,1},b_{j,2},\ldots b_{j,u_j}\}\subseteq\Sigma$ with $u_j=|C(t_j)|$. In order for transition t to be enabled, there must exist a binding in which guard expression $G(t)$ evaluates to . $T\in B$. In the same binding, the multi-sets of tokens of appropriate colours, as specified by the input arcs expressions, must be present in all input places of transition t. When enabled, transition may fire. Firing of transition t generates multi-sets of tokens in output places of t, and consumes multi-set of tokens from input places of t, as specified by the arc expressions.

Considering that the temporization of a coloured PN can be achieved by attaching time either to places, to transitions or to the expression functions of arcs (Jensen, 1997). In this work the second option is chosen and timed transitions and immediate transitions are considered. Precisely, FT denotes a timing vector and the firing time of each transition t_j is the positive number $FT(j)$ specifying the deterministic duration of the firing of t_j. In this method, a token has a time stamp attached to it, in addition to token colours. The time stamp is described by the function $s:C\rightarrow\Re^+$ where $s(c)$ indicates the earliest delay after which the token of colour $c\in C$ becomes available and can be removed by an enabled transition. Hence, as soon as the c-colour token arrives to the place p_i enabling transition t_j, $s(c)$ is set to FT_j. Accordingly, after

FT_j time instants the enabled transition t_j becomes ready to fire with respect to colour c. If FT_j is equal to zero, the transition is said to be an immediate transition.

3 Event-driven simulation model of the AGV traffic with hierarchical timed CPN

Timed CPN model will be applied to traffic control of an AGV during unloading containers from the ship and transporting them to the stacking crane. Each container job involves the loading of a container onto the AGV, the movement of the AGV to the destination of the container, and the unloading of the container from the AGV. An AGV can be assigned one job at a time. After completing a job, an AGV can start another job.

Proposed CTS system consists of two cranes (QC(1) and QC(2)) and two stacking crane (YC(1) and YC(2)) which unloads containers from AGV and loads them on the stack. Timed CPN model of described process of transferring containers using AGV vehicles in the port transport terminal is shown in Image 3. For the construction of the network and the simulation was used Design / CPN tool.

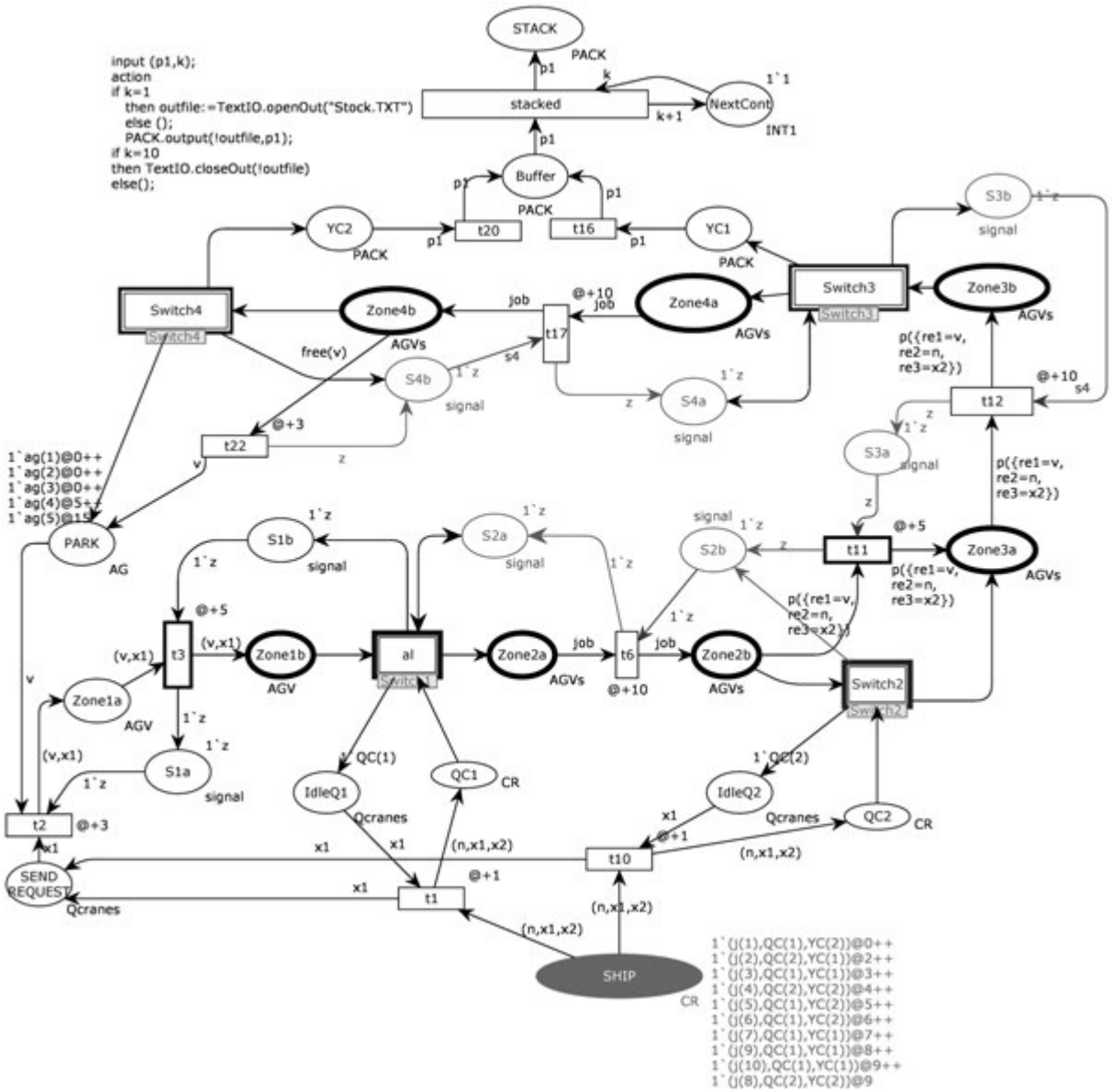

Image 3: CPN model of AGV traffic layout

3.1 Implementation of the zone control model

The following four components are modelled as material flow objects in our simulation model: Zone, Crossing, Stack, Yard and vessel. There are four zones and places denoted as $Zone_i a, Zone_i b$ $(i = 1,2,3,4)$represent the checking points equipped with sensors. The place Parking represents the place where free AGVs are parked. The variables ag(1), ag(2),…, ag(5) are token colures for that place and represents five parked AGV vehicles. The transitions *Switch1*, *Switch2*, *Switch3* and *Switch4* are substitution transitions. In contrast to ordinary transitions, substitution transitions represent modules - substitution subnet composed of set of places and transitions.

The place *ship* is input place and represents the ship the start point for container transportation. Variable $(n, x1, x2)$ is set according to the colour tokens that are associated to

the considered place. Ordered three dimensional variable $(n,x1,x2)$ consists of the variable $n\in(j(1),j(2)\ldots,j(10))$- set of container to be transported from the ship; variable $x1\in\{QC(1),QC(2)\}$- ordinal number of a quay crane; $x2\in\{YC(1),YC(2)\}$- ordinal number of a yard crane. If there is no token in this place means that there no containers are to be moved from the ship. For example, let's the token with colour $(j(2),QC(2),YC(1))$ in the place *ship*. It means that the container 2 has to be transported from the quay crane 2 to the stock crane 1 on the storage area. When quay crane unloaded a container from the ship, it has to put the container on an AGV (represented as the transition t2 in the Image 3). After that, this vehicle transports the container to the yard crane where the container to be unloaded from the AGV (transitions *Swich3*, *Switch4*).

The transitions denoted with *Switch* represent the crossing places. Image 4 shows Switch1 layout. When t4 transition is fired a token is moved into the place *Zona*2a or into the place SW1. It means the an AGV moves to the zone 2 or it turns to the quay crane *QC*(1).

The direction of the movement is evaluated and the required direction for the vehicle is chosen. When a token with colour (v, x1) comes in Zone1b, the situation is analyzed and the vehicle is stopped or its movement continues.

As permitted in a zone/switch to be only one AGV, at beginning and end of each zone and switch are places denoted as *Sia, Sib* or *SeSWi* (*i*=1,…,4). The colours of tokens in these places correspond to green and red traffic lights.

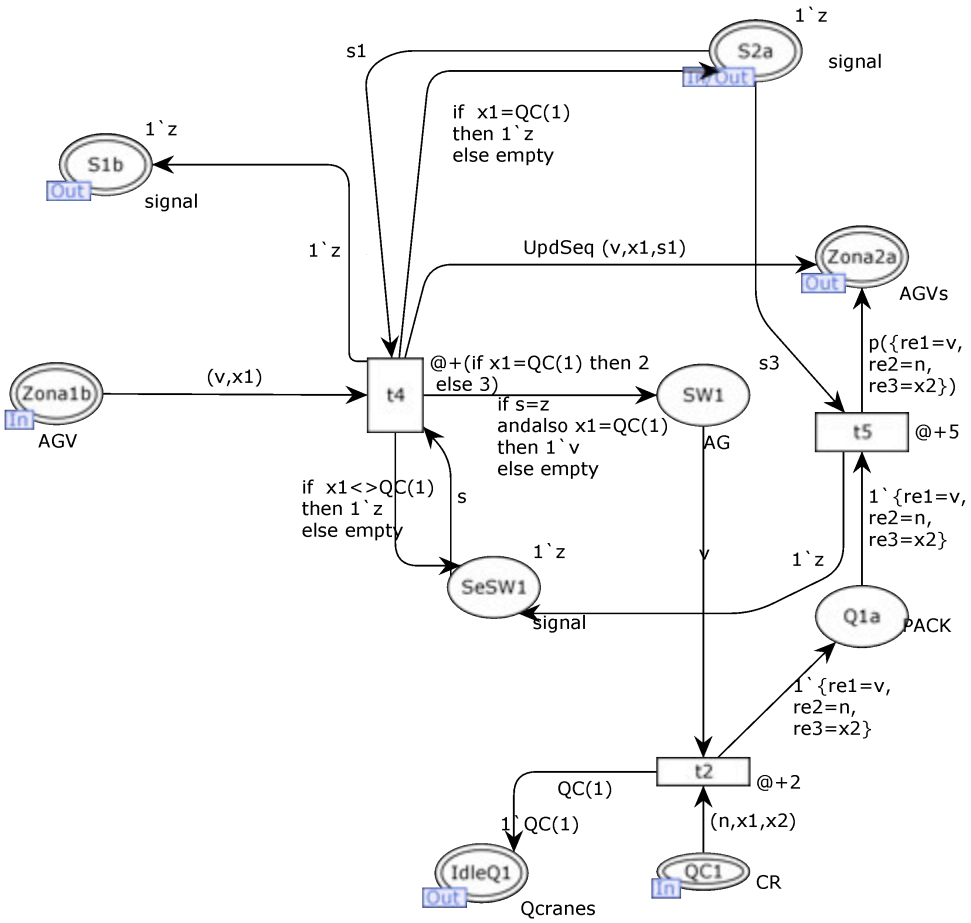

Image 4: CPN subnet for the transition *Switch1*

3.2 Modelling of time

The main difference between timed and untimed CPN models is that the tokens in a timed CPN model—in addition to the token colour—can carry a second value called a time stamp. In general, a time stamp can be a non-negative integer or real. In the current CPN model only non-negative integers are supported. The time stamp tells us the time at which the token is ready to be used, i.e., the time at which it can be removed from the place by an occurring transition. As an example, the initial marking of the place SHIP is:

1`(j(1),QC(1),YC(2))@0++
1`(j(2),QC(2),YC(1))@2++
1`(j(3),QC(1),YC(1))@3++
1`(j(4),QC(2),YC(2))@4++
1`(j(5),QC(1),YC(2))@5++
1`(j(6),QC(1),YC(2))@6++
1`(j(7),QC(1),YC(1))@7++
1`(j(9),QC(1),YC(1))@8++
1`(j(10),QC(1),YC(1))@9++
1`(j(8),QC(2),YC(2))@9

The time stamp of tokens are written after the @ symbol.

In reality CT, any resource requires nonzero times for performing jobs. In our CPN, time inscriptions are attached to the transitions. These times represent the time units needed that an AGV pass through the single zone or switch. This will allow us to evaluate how efficiently a system performs its operations. In Image 3 we have attached a time delay inscription @+5 to the t3 transition. It is now also necessary to calculate the time stamps to be given to the output tokens. The time stamp given to the output tokens is the value of the global clock plus 5 units. Intuitively, this represents the fact that an AGV can't leave the zone 1 until 5 time units after the end of the previous operation.

Furthermore, the CPN model has a global clock representing model time. In a hierarchical timed CPN model there is a single global clock that is shared among all the modules. The tokens on a place will carry a time stamp if the colour set of the place is timed.

3.3 Simulation results

After a number of simulation steps the timed CP-net may reach a dead final marking with the contents shown in Image 5. The simulation finished after 233 time units. From the time stamp of STACK it can be seen that the last packet was received at time 230. It observed that there is no conflict and deadlocks in the system, because the number of AGVs in resources (zones or switches) is, as a rule, limited due to one. If by the execution of a route a collision occurs and process control realizes an exceptional stop of an AGV. For instance, markings of Z1b and SW1 places are shown in Image 6. It is observed that only one AGV is presented in both places in every time stamp. If the switch 1 is occupied in a moment of time, and if there is an AGV in the zone 1 waiting to pass thought Switch 1, then this AGV waits for the availability of the occupied switch. When the switch becomes available, it is occupied by awaiting AGV.

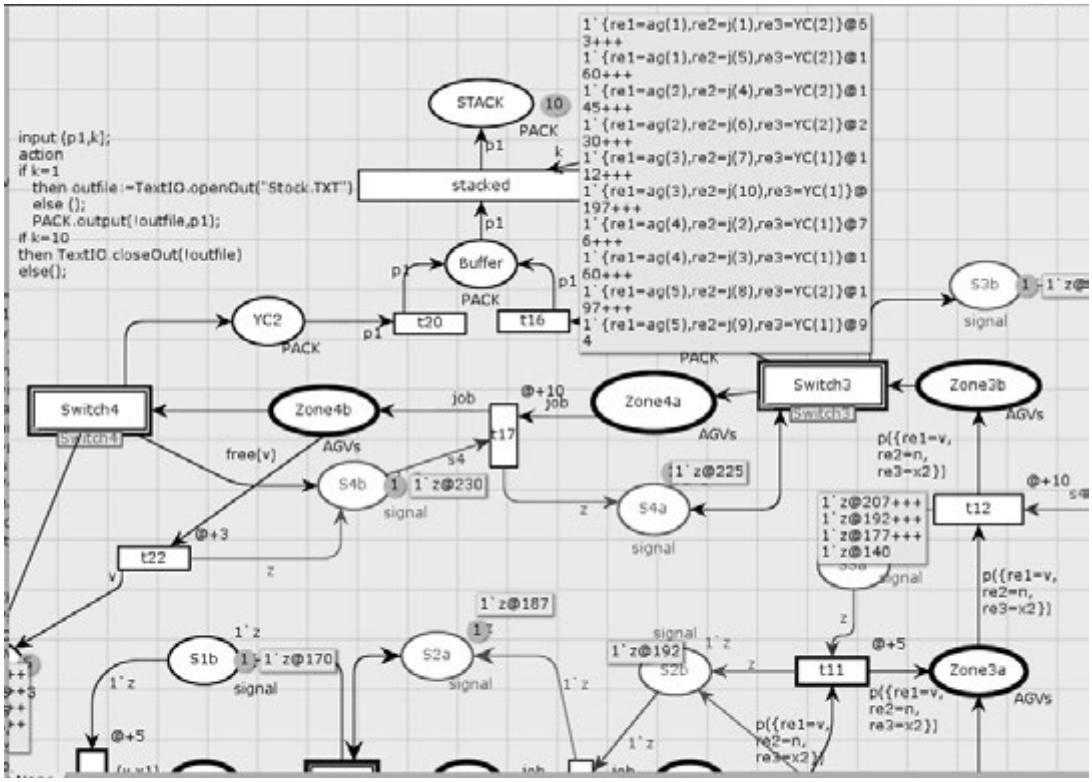

Image 5: State space fragment for CPN model at the end of the simulation

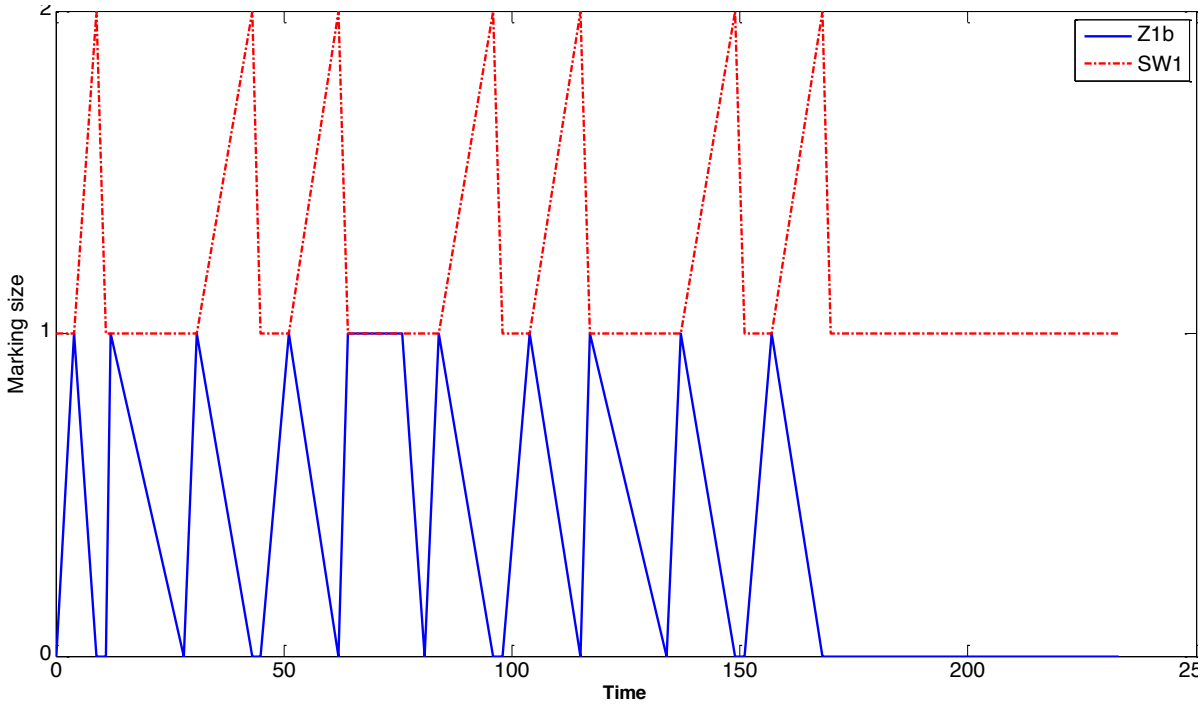

Image 6: Number of AGV in the zone 1 and in the switch 1

4 Conclusion

A suitable AGV timed CPN model and control problems in container terminal systems are introduced in this paper. The zone control approach is used here to ease the traffic management. A traffic control scheme is developed. Computer simulations demonstrate the efficiency of our results in terms to avoid conflict and deadlocks in systems. The proposed approach is suitable for any complex traffic system.

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How do Learning Styles, Time Management and Learning Material Presentation Affect Task Performance in a Hybrid Learning Environment?

Mario Jadrić
University of Split, Faculty of Economics, Croatia
mario.jadric@efst.hr

Maja Ćukušić
University of Split, Faculty of Economics, Croatia
maja.cukusic@efst.hr

Željko Garača
University of Split, Faculty of Economics, Croatia
garaca@efst.hr

Abstract

To implement e-learning tools and concepts properly in a higher education hybrid learning environment it is necessary to make appropriate educational decisions. Issues investigated in this research study are: is there a difference between the result achieved by students of different preferred learning styles when the mode of delivery of materials is either textual or visual; can the way of learning material presentation affect the success in tasks given to students regardless of the preferred learning style. In addition, given that the tasks in online and hybrid learning environments are usually time-limited, the question is does time management skill affect the results of students. These questions were explored in an experimental study with 444 university students enrolled in a course that runs in a hybrid learning environment. The students were randomly divided into 12 groups, with six groups accessing e-learning material, a description of a procedure, delivered in plain text format while the other six groups accessed e-learning material in the form of a diagram/picture illustrating the same procedure. The materials were comparable in terms of learning content. Research results indicate that scores achieved by students on a time-limited test are not influenced by students' preference towards a particular learning style, but are more related to other factors such as the ability to manage the available time, computer skills, whether or not a topic is interesting and structure of the materials. The implications of the results may be important in the context of decision-making process in terms of selecting between two types of e-learning material in a hybrid learning environment.

Keywords: learning styles, time management, learning materials, higher education

1 Introduction

The teaching and learning processes changed over the past decade(s) due to the rapid advances in technology and communications. Information technology advances with such speed that some knowledge and skills quickly become obsolete, and consequently the educational cycle must be continuous and lifelong so as to qualify individuals for being productive members of society. New teaching and learning paradigms place the learner in the center i.e. participants take on more responsibility, while the instructor is there to support and provide adequate strategies, tools and advice for successful e-learning (Mankell, 2006). The instructional designers and/or teachers are to select the most suitable learning strategies based on well-known, proven principles depending on the context of use and supported by the appropriate use of technology (Singh & Reed, 2001). Because of different possibilities brought forth by hybrid learning environments, the complexity of its implementation strategies increases. Other than choosing the right ratio between online and traditional learning, the hybrid learning instructors have to face other problems and opportunities that characterize both environments (the online and traditional one). Bliuc et. al. (2007) refer to hybrid learning as all learning activities that systematically combine face to face interaction and technologically mediated interactions between students, teachers and learning content.

There are a number of decisions that instructional designers have to take to shape the interactions between students, teachers and learning content. Khan (2001) distinguishes important dimensions of e-learning encompassing both technical and pedagogical dimensions such as: learning objectives, content, design, organization, methods and strategies, and resources applicable to an e-learning environment.

Weistra (2000) points to the importance of the content and interaction as the most important dimensions of e-learning pedagogy. The learning content can be offered by the instructor in a structured manner or can be freely explored by students in a manner they choose. The level of interaction can range from not possible to strong interaction with other students and instructors. The author has thus identified two dimensions related to instructors' methodological dilemmas: interaction with the learning content and ICT-mediated communication between the learners.

Of relevance to our research is the importance of the decisions related to interaction with e-learning content. Considering the implications of cognitivist approach to e-learning, Ally (2004) states that: the content should be "fragmented" to prevent learning "overload" during their processing; online materials should provide activities for different learning styles so that students can choose the activity that suits their style of learning; and that information should be presented in different forms in order to meet as many differences between individuals. On the other hand, Allen (2007) lists constructivist viewpoints arguing the knowledge, understanding and skills cannot be directly transferred. If the presentation of knowledge (learning material) is cut up into small pieces (which is something that instructional designers in e-learning environments often do), they are actually stripped of one of the important learning components. Participants have to collect and adapt the fragmented material to their way of thinking as an additional activity.

1.1 Learning styles

Learners often have general ideas about their preferred representations of the learning content. As an example, some prefer visual representation in the form of diagrams, pictures etc., while others prefer verbal representation that can either be read or listened to. In short, different people learn in different ways. The preference or the learning style is a specific way of

learning, and processing of data obtained about the outside world (Čudina-Obradović i Brajković, 2009).

Compatibility of cognitive styles and the technology used is one of the important research fields in e-learning since it directly affects the perception of the effectiveness of learning, motivation and performance. In the case where the cognitive style is compatible with the technological solution for presenting content, individuals pay better attention and understand relevant information resulting in better learning outcomes (Workman, 2004). A distinction is made between cognitive abilities and styles (e.g., cognitive styles, learning styles) (Kollöffel, 2012) although these terms are not always used in the consistent way. While cognitive abilities refer to general and specific intellectual capabilities, cognitive styles refer to dominant or preferred modes of perceiving, remembering, thinking, and problem solving (ibid). Frequent example of a cognitive style is the difference between "visualizers" and "verbalizers" already listed above has been inspected, among others, by Massa and Mayer (2006) who found that students who prefer visual modes of presentation tend to select pictorial help screens whereas students who prefer verbal models of presentation tend to select verbal help screens.

Felder-Silverman learning style model (Felder & Silverman, 1988; Felder & Spurlin, 2005) is often used to categorize different types of learners, and is used in the empirical part of this research as well. Namely, the model differentiates between active/reflective, sensing/intuitive, visual/verbal and sequential/global learners. As an example, active learners prefer hands-on approach first whereas reflective learners tend to think about and reflect on it first. Accordingly, sensing learners prefer to learn facts and concrete data while intuitive learners prefer to learn abstract concepts and to discover relationships. Visual learners tend to remember best what they see in graphical representation whereas verbal learners remember better written or spoken words. Finally, sequential learners prefer learning in linear and logical steps while global learners learn better in random and large leaps.

Depending on how the material is presented (and this is directly related to learning style), it is possible to observe the effectiveness of an e-learning course and retention of the program (Frye, 1999). It has been proven that a good match between format and preference promises to facilitate learning processes and to enhance learning performance (Klein, 2003).

1.2 Time management skills

Many authors offer advice on how to best manage time to successfully meet all the demands of online learning programs (Fraser, 2010; Coglin, 2009; Sink, 2006). It should be noted that good time management skills are one of the important characteristics of successful students, whether it comes to online courses or traditional instruction environment. Blocher et al. (2002) report that students need to be self-disciplined, and have to independently monitor and control their learning process to be successful in an online course. Kerr et al. (2006) established a clear link between the time management skills and students' success. For this purpose, they examined the way students organize their time, set priorities for solving tasks, whether or not they can self-discipline and organize time for learning and so on. Since the tasks we presented the students with were time-limited, we opted for inspecting students' time management skills as well.

1.3 Computer skills/literacy

Additional to basic abilities to use a computer system (including file management, opening, copying, and printing documents, solving personal and business tasks, using a web browser

and search engines, emailing etc.) that define computer literacy (Gupta, 2006), other types of computer literacy are often mentioned such as the ability to use online gaming, synchronous and asynchronous communication and creation of blogs, web pages and multimedia content (Lankshear & Knobel, 2003). Learners with higher levels of computer skills generally have more favorable attitudes toward e-learning (Roberts & Dyer, 2005). Participants who lack computer skills are faced with frustration and often drop out from e-learning courses. There are evidence that after attending formal computer literacy building courses, students become more willing to use ICT in their studies and future professional career (Sorebo et al., 2009).

Basic computer skills required to access and navigate the online environment, such as sending and receiving e-mail, downloads, educational materials, using forums and chat rooms, are key to online success of the participants (Madernach et al, 2006; Selim, 2005). Therefore, we inspected the level of computer skills of the participants in the study so as to control whether some of them had anxiety towards the use of technology in hybrid learning context.

1.4 Representational format of learning material

Information technology provides instructors with opportunities to supplement / adjust the formats used in learning environments to the preferences of individual learners (Kollöffel, 2012). Presenting material in different ways is beneficial for students. Although students might find a certain representational format (e.g., diagram, text) more attractive than other formats for learning, there are different advantages to using one or the other form, e.g. readers can easily adjust the pace of reading and reread if necessary (Merkt i Schwan, 2014). As already mentioned, many studies test the link between learning styles and achievement/success indicators. Few studies however, focus on the difference between the visual and textual representation of learning content to prove the visualizer-verbalizer learning style hypothesis using real learning materials (Kollöffel, 2012) and vice-versa, studies focusing on learning material effectiveness do not take into account individual differences and learning styles.

Similar to other e-learning practitioners' dilemmas our research was motivated by the idea of matching the individual's preference (or style) and the representational format of the learning materials in hybrid learning context of a higher education institution.

2 Research method

2.1 Participants

The participants of the study were the first-year students of the University in Split, Faculty of Economics. The respondents come from a relatively homogeneous group (first-year students) and mostly share a similar background in terms of education, economic situation etc. General statistics of the sample population is presented in Table 1.

Data was obtained using an online survey tool. The questionnaires were completed voluntarily and anonymously by students after compulsory classes finished. The exercise was conducted in a proctored environment, i.e. in computer labs and under supervision of a teaching fellow. The students were instructed to access the link to the online questionnaire which was placed on the official e-learning website of the Faculty. They were instructed to close any other programs running on their computers. They were given enough time to complete the questionnaires finishing in approximately 30 minutes. A total number of 444 questionnaires were valid and analyzed.

		Group 1: Diagram (N=222)		Group 2: Text (N=222)		Total (N=444)	
		N	%	N	%	N	%
Gender	Male	65	29.3%	59	26.6%	124	27.93%
	Female	157	70.7%	163	73.4%	320	72.07%
Age	18-19	191	86.04%	194	87.39%	385	86.71%
	20-21	24	10.81%	22	9.91%	46	10.36%
	22 and more	7	3.15%	6	2.70%	13	2.93%

Table 1: General statistics

In academic year 2013/2014 total of 593 students were enrolled in first-year study programs. 444 students participated in the experiment. Based on gender and age of the participants it can be considered that the sample is representative when compared to the total population and between two groups. Majority of the students are female (slightly above 70%) and with regards to age, old between 18 and 19 years (around 87%).

2.2 Learning material (visual vs. textual presentation)

Among other determinants, the purpose of the research was to determine is there a relation between learning style, representational format of the learning materials, and learning performance. Two scenarios were inspected that differed from each other with respect to the representational format of the learning materials (see image 1). In one scenario the learning materials was visual (diagram), while in the other scenario the instructional material was verbal. In order to make a fair comparison, the representational formats used in both scenarios were selected and prepared based on the following criteria:

- The content (the meaning) in both scenarios was identical, except for the representational format used to present the subject matter. The domain of the instruction was from business process management and quality system management.
- The representations used in both scenarios were equivalent in terms of conveyed information, i.e. they were "informationally equivalent" meaning that one representation can be built on basis of the other and vice versa.
- The required time to process these two scenarios/materials was equivalent.

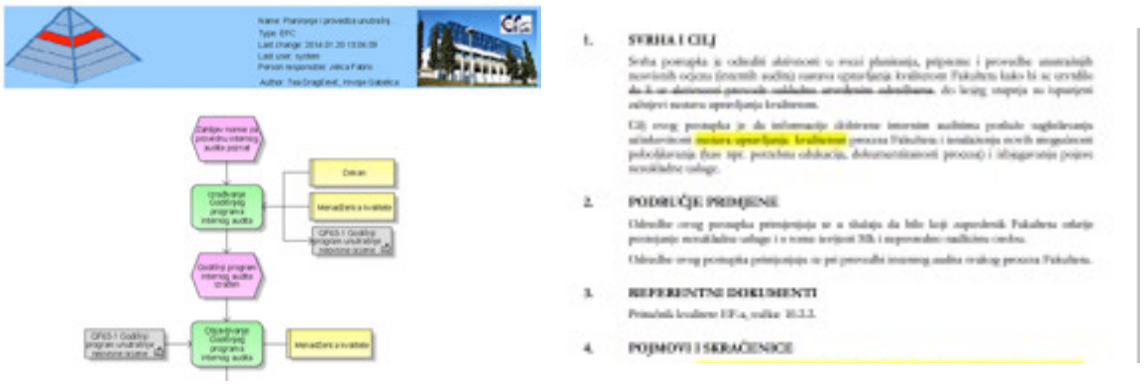

Image 1: Different representational format of learning materials

2.3 Research instrument and procedure

The questionnaire was divided in 3 segments (illustrated in image 2).

The first part was designed to collect demographic information of the respondents (as shown in table 1 above). Other than the 4 questions related to gender, age and course of study the remaining questions were prepared/translated from the Index of Learning Styles (ILS) (Felder & Silverman, 1988; Felder & Soloman, 1993) with the aim to identify students' learning styles. This section consisted of 44 questions, with each question item having two different options. Consequently, learning styles were evaluated on four dimensions: processing (active/reflective), perception (sensing/intuitive), input (visual/verbal), and understanding (sequential/global). Each dimension was measured by 11 items. In ILS, respondents were asked to rate themselves on each item by choosing the most appropriate (only one!) option per question. Their choices were converted into scores based on ILS calculation method taking into account that score of 1 to 3 on a dimension indicates a fairly well balance on both sides of that dimension, while a score of 5 to 7 indicates a moderate preference for one side of a dimension and a score of 9 to 11 indicates a very strong preference.

Part 2 contained the link to learning material and, based on the material, 6 multiple choice questions with 6 possible answers out of which one or more was correct. Wrong answers were scored with negative points. The exercise was time-limited to 7 minutes.

Part 3 contained 12 additional Likert-type questions measuring time management skills, computer literacy, learning material preference and learning material structure.

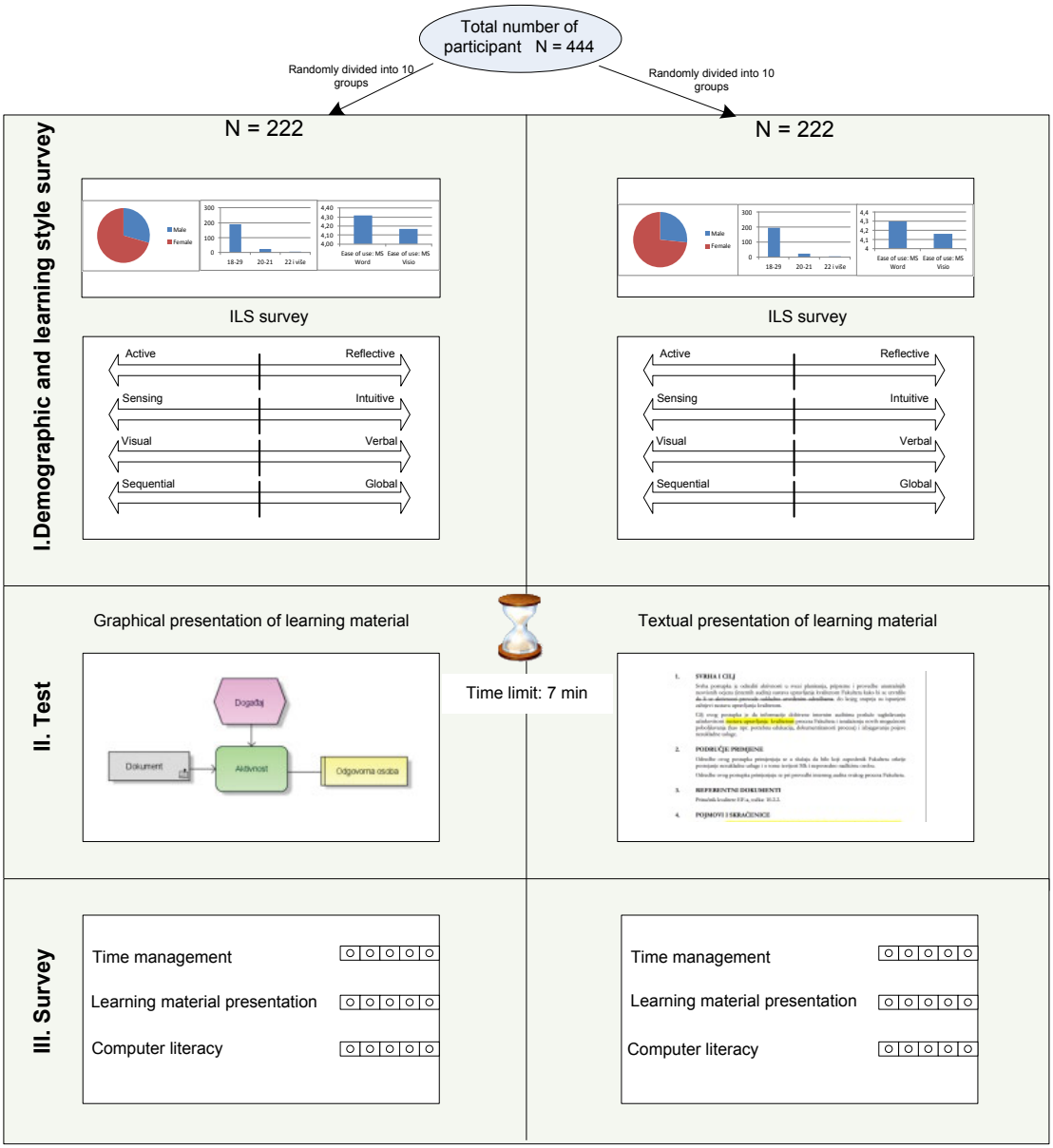

Image 2: Research procedure

3 Research results

3.1 Learning styles

The results of students' learning styles are presented in table 2. The most preferred learning style of the participants was visual learning (81.53%) followed by active learning (78.60%) and sensing learning (78.38%), indicating that the majority of participants learned best when information was presented in visual format such as pictures or diagrams (cf. Cheng, 2014). The results are in line with the findings of Willems (2011) stating that most of undergraduate learners in Humanities, Communications and Social Sciences are visual learners.

	Group 1: Diagram (N=222)					Group 2: Text (N=222)					Total (N=444)	
	1-3 MLD	5-7 MOD	9-11 STG	N	%	1-3 MLD	5-7 MOD	9-11 STG	N	%	N	%
Active	93	68	17	178	80.18%	81	68	22	171	77.03%	349	78.60%
Reflective	32	10	2	44	19.82%	43	7	1	51	22.97%	95	21.40%
Sensing	63	86	32	181	81.53%	53	67	47	167	75.23%	348	78.38%
Intuitive	27	7	7	41	18.47%	35	16	4	55	24.77%	96	31.62%
Visual	54	65	56	175	78.83%	57	77	53	187	84.23%	362	81.53%
Verbal	37	9	1	47	21.17%	26	8	1	35	15.77%	82	18.47%
Sequential	101	62	11	174	78.38%	103	59	9	171	77.03%	345	77.70%
Global	36	9	3	48	21.62%	45	3	3	51	22.97%	99	22.30%

Table 2: Learning style preferences

It can be observed that when comparing the preferred learning style between the two groups (Group 1: Diagram and Group 2: Text) there are minor differences in the distribution; specifically with sequential and global learning styles the differences are minimal.

3.2 Learning efficacy of separate groups given different learning material (visual vs. textual presentation)

The difference in the results achieved on the test between the two groups of students is presented in table 3. On average, students that based their answers on visual representation of the learning material achieved better results (43.71 out of 100) as opposed to those that based their answers on verbal representation (written test).

Based on the presented results, it can be claimed that test results in the first group (the group of students who studied the material in the form of a diagram) are better because majority of students (81.53%) consider themselves as visual learners. Within two groups the percentage of visual learners is similar leading to conclusion that the higher the number of preferred visual learners (78.83%) in the first group (diagram) influenced the better result of the group, while the smaller number of verbal learners (15.77%) in the second group (text) influenced the lower test performance of the group. In order to inspect this assumption the results of testing differences between means for preferred learning styles and achieved test scores between groups and for all the participants are presented hereinafter.

		Mean	Std. Dev.	Std. Error Mean
Test results	Group 1: Diagram (N=222)	43,7162	17,73525	1,19031
	Group 2: Text (N=222)	31,5721	16,96154	1,13838

Table 3: Results of the test based on different learning material

3.3 Relation between learning styles and test scores

The difference in the results achieved on the test between the two groups of students and in relation to their learning styles is presented in table 4 for each group and for all the participants.

Although results presented earlier (in section 3.1. and 3.2.) indicate that students (on average) prefer a visual learning style, and that better results (on average) are achieved by students who studied the material in the form of a diagram, the results presented in table 4 show that there are no significant statistical differences in the results achieved with respect to any of the preferred learning styles. Although, for example, students who prefer a visual learning style achieved on average a better result (mean score 44.52%) than students who prefer verbal learning style (mean score 40.72%) there is no statistically significant difference when their material is provided in the form of diagrams. In the second group (text), the students who prefer verbal learning style achieved better scores on average (mean score 31.82%) compared to those who prefer visual learning style (mean score 31.52%) but the difference is minimal and not statistically significant.

	Group 1: Diagram (N=222)			Group 2: Text (N=222)			Total (N=444)		
	Mean	Std. Dev.	p-value	Mean	Std. Dev.	p-value	Mean	Std. Dev.	p-value
Active	44.5449	17.12436	0.162	31.1988	15.95900	0.549	38.0057	17.83835	0.427
Reflective	40.3636	19.87881		32.8235	20.08951		36.3158	20.24176	
Sensing	43.0497	17.86346	0.240	31.3174	16.40639	0.698	37.4195	18.13150	0.624
Intuitive	46.6585	17.05815		32.3455	18.68572		38.4583	19.27798	
Visual	44.5200	18.07896	0.193	31.5241	17.27927	0.923	37.8066	18.80609	0.696
Verbal	40.7234	16.22358		31.8286	15.38044		36.9268	16.38185	
Sequential	44.3621	17.70376	0.303	31.1579	16.88541	0.507	37.8174	18.49917	0.711
Global	41.3750	17.83807		32.9608	17.31353		37.0404	17.98351	

Table 4: Learning styles in relation to test scores

There are no larger differences in test results with regards to preferred learning styles when seen through prism of high and low test performance (for 25% of the best and 25% of the worst students). Visually, the difference between the worst and the best test scores for two groups is presented in image 3. Among the students that solved the test with lower scores there is a slightly larger number of students from the group that solved the test based on the textual/verbal material.

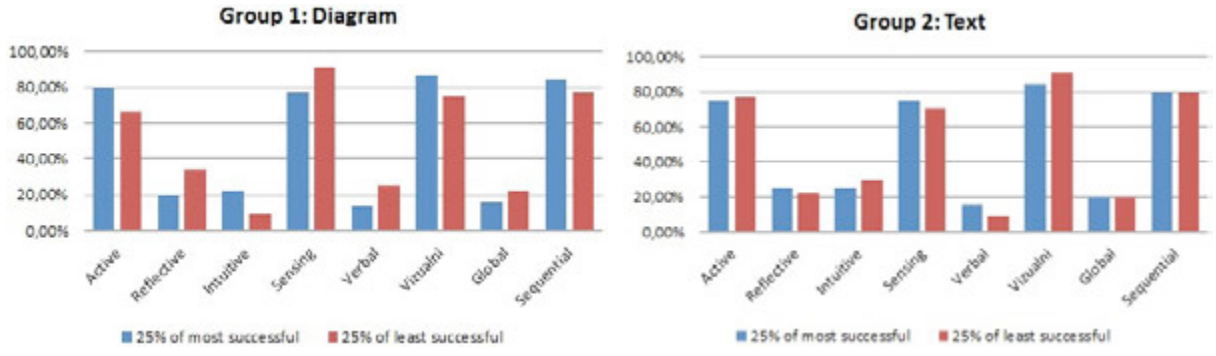

Image 3: Best and worst test scores for two groups of students

3.4 Relation between time management, learning material presentation, computer literacy and test scores

Correlations between determinants such as time management skills, learning material presentation, computer literacy and test scores are presented in table 5.

Participants from both groups expressed their agreement with statements related to computer literacy with an average score of above 4 (out of 5). Therefore, there is no statistically significant difference between the two groups with that regard. However, for all remaining statements related to time management skills and learning material representation, students from the first group rated statements on average higher (Group 1: diagram) this being statistically significant difference.

Furthermore, for all the observed variables there is a weak but statistically significant correlation with the test results taking into account all the participants regardless of the learning material presentation. Within the first group (Group 1: diagram), there is a weak correlation between the results of the test and 2 (out of 2) statements related to time management skill, one statement about the learning material representation and one statement related to computer literacy. Within the second group (Group 2: text), there is a weak correlation between the results of the test and one statement related to time management and two statements referring to computer literacy.

		Std. Error Mean Between Groups			Correlation Within Groups		Correlation Total	
		Mean	Std. Dev.	p-value	Corr.	Sig. (2-tailed)	Corr.	Sig. (2-tailed)
The available time was sufficient to carefully study the material.	Group 1: Diagram (N=222)	3.53	1.116	0.000	**0.197****	0.003	**0.253****	0.000
	Group 2: Text (N=222)	2.57	1.162		0.091	0.174		
I made good use of the available time to study the material.	Group 1: Diagram (N=222)	3.35	1.073	0.000	**0.268****	0.000	**0.288****	0.000
	Group 2: Text (N=222)	2.66	1.080		**0.146***	0.029		
The material is presented in an interesting way.	Group 1: Diagram (N=222)	3.50	1.108	0.000	0.034	0.612	**0.133****	0.005
	Group 2: Text (N=222)	2.35	1.094		-0.087	0.195		
Finding answers in the material was easy.	Group 1: Diagram (N=222)	3.39	1.061	0.000	0.126	0.060	**0.182****	0.000
	Group 2: Text (N=222)	2.66	1.046		0.034	0.614		

The content was well structured and logical.	Group 1: Diagram (N=222)	3.60	0.900	0.000	0.093	0.168	**0.171****	0.000
	Group 2: Text (N=222)	2.92	0.976		0.037	0.584		
The material I have read/viewed was sufficient to answer the test questions.	Group 1: Diagram (N=222)	3.69	0.945	0.000	**0.168***	0.012	**0.231****	0.000
	Group 2: Text (N=222)	3.07	0.998		0.123	0.068		
I easily use the functionalities of the standard word processing software (e.g. MS Word).	Group 1: Diagram (N=222)	4.32	0.820	0.772	**0.148***	0.028	**0.147****	0.002
	Group 2: Text (N=222)	4.30	0.815		**0.154***	0.021		
I easily use the functionalities of the standard software for creating diagrams, illustrations (e.g. MS Visio).	Group 1: Diagram (N=222)	4.17	0.833	0.864	0.113	0.093	**0.126****	0.008
	Group 2: Text (N=222)	4.16	0.833		**0.149***	0.026		

Table 5: Correlations between various determinants and test scores

4 Conclusion

In general, the results indicate that majority of students prefer visual learning style (81.53%) followed by active learning (78.60%), sensing learning (78.38%), and sequential learning (77.70%). For the described structure of the respondents (first-year university students with orientation in business studies; N = 444), no clear link between preferred learning styles and modes of learning materials' delivery in this specific environment and for time-limited tests can be observed. However, for the described student population the strongest correlation was between students' test results (irrespective of one or the other mode of learning materials' delivery) and variables representing time management skills, then presentation of the materials (sufficiency, structure, logic, navigation) and computer literacy.

Hence, research results indicate that scores achieved by students on a time-limited test are not influenced by students' preference towards a particular learning style, but are more related to other factors such as the ability to manage the available time, computer skills, whether or not a topic is interesting and the structure of the materials.

The findings are in line with the previously mentioned research by Kollöffel (2012) who proved that cognitive/learning style and learning outcomes were unrelated. More specifically, learners with either moderate or strong preference for visual materials do not necessarily perform better on test based on visual learning materials. On the other hand, the results seem to be related to other learning material characteristics, rather than a match between used and preferred format.

The implications of the results are important in the context of decision-making process in a hybrid learning environment. Instructors are faced with choices between different types of e-learning material described in detail in the introductory part of the paper. The results of the

study imply that instructors and students should not prepare/choose learning materials on the basis of their preference, since the choice might lead to selecting a format that is less effective for learning.

As this study shows statistically significant correlations between statements representing time management skills with the results achieved in a time-limited test, the question remains: would the results differ in case no time limit was set? Even though such kind of tests are rare in university classroom practices the question is relevant especially in hybrid learning environments where self-assessment tests without time limits are often exercised. Another relevant question is would/how the results differ if students had more time to study the material (e.g. one week, one month or the whole semester). As these two issues are somewhat limiting the findings of this research, at the same time these limitations form guidelines for future research in this area.

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Modeling and Control of Power Management System on Ship

Maja Krčum
University of Split, Faculty of Maritime Studies, Croatia
mkrcum@pfst.hr

Anita Gudelj
University of Split, Faculty of Maritime Studies, Croatia
anita@pfst.hr

Veljko Plazibat
University of Split, Faculty of Maritime Studies, Croatia
veljko.plazibat@pfst.hr

Abstract

Electrical system of ships is autonomous systems. The prime movers including diesel engines, gas/steam turbines, are integral parts of the systems which produce energy for large consumers (for example thrusters, propulsion systems, drilling systems etc.) and "small" consumers (navigation, lights...). The complexity of vessels such as cruise vessels, ice breakers or vessels where much manoeuvring is required (frequent change in propulsion load) requires dependable electrical power for operation, integrity of the well and safety – of both the installation and its personnel. Safe, secure and efficient shipping on clean ocean, suggested by International Maritime Organization (IMO), requires the development of appropriate design, operational knowledge and assessment tools for energy efficient design and operation of ships. In this paper we analysed the hybrid renewable energy system. The design of future ship will require the development of new and increasingly sophisticated methods for the modelling and simulation of the complex systems that must be integrated in order to produce the total energy for the ship. Control architecture for power distribution systems has to be hierarchical, distributed and easy to adapt. A complete logistic chain of this control architecture will be modelled by Colored Petri Net (CPN), which connects effective agents for autonomous control of complex distributed systems with agents for the control of power management systems.

Keywords: ship power system, renewable energy on ship, Colored Petri net

1 Introduction

the subsequent denial of insurance due to safety fears of electrical fire, the electrical power plants in modern ships have grown in size and complexity with the growing demands on ship size, speed, economy, safety, comfort and convenience. From the original electrical power, few kW at 120 V, some of today 's navy and cruise ships require an electrical load of over 100

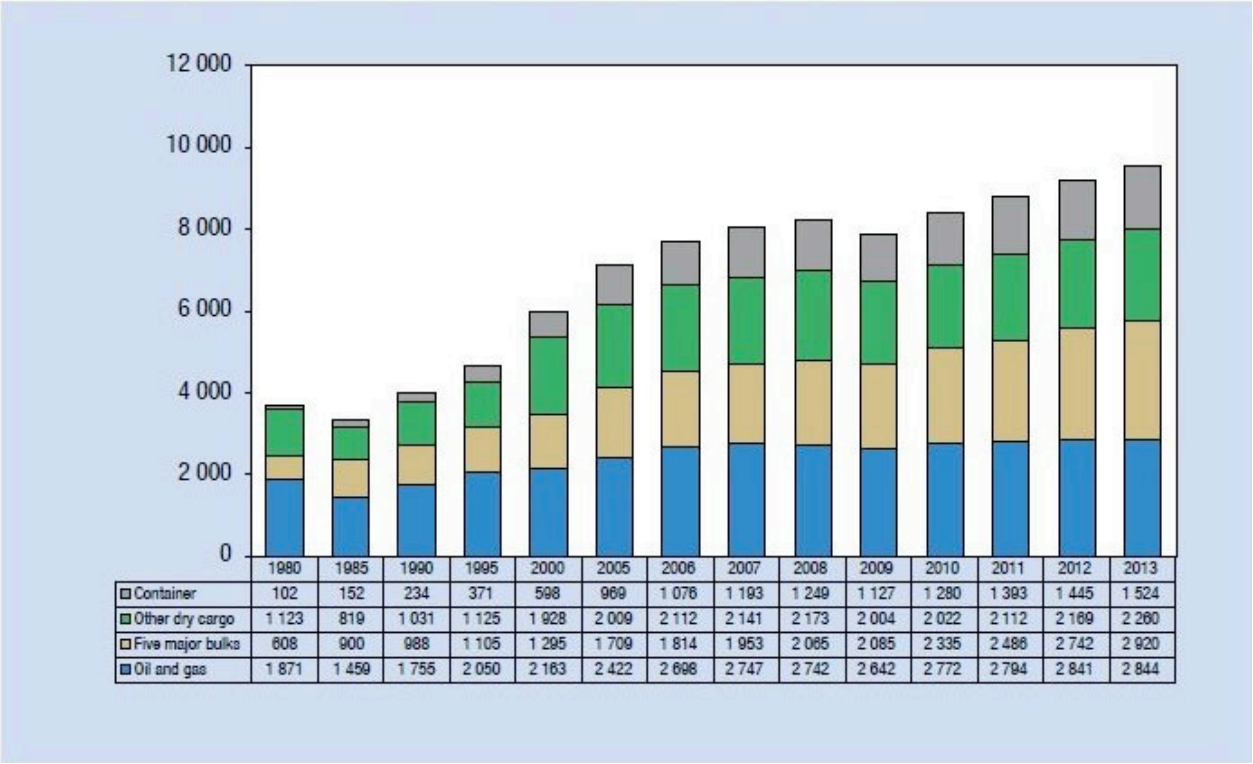
MW at a voltage of 11 kV or higher. In the past decade, there has been a strong trend for more electrification on naval and commercial ships. Large passenger cruise lines that are being designed today may be 350 m long and 40 m wide to serve about 4500 passengers with 1500 crew members. These trends indicate that electrification in the shipping industry is a growth area. Ships are autonomous systems with their own power plant on board, and the demands placed on these power plants very just as widely as the ship themselves. The shipboard power system designed generally requires the following tasks: selecting the optimum power system configuration an voltage level best suited from the ship; load analysis to size the electrical generator kW and kVA ratings and the prime mover s kW retain; power distribution routing for propulsion and service loads; sizing the feeder cables for required capacity and limiting the voltage drops per the applicable standards (usually 3%-5% of the rated voltage at steady state); fault current analyses and protection device ratings at key locations, determining the sensor types and locations to monitor the system. Some tasks offer a great deal of designed challenges and opportunities related to the power system analysis that meet all imposed or self-drive requirements in steady state and transit conditions. More than dozen power system modelling, simulation and analyses tools are available in the market to help the design engineer perform these tasks.

Maritime transport is an important mode of transport from the European Union with over 90% of its external trade and some 43% of its internal trade going by sea. The maritime sector is also important from an economic point of view. Maritime companies belonging to European Union nationals control one third of the world fleet and some 40% of EU trade is carried on vessels controlled by EU interests. The environmental record of maritime transport is mixed. On the one hand, sea shipping is relatively climate friendly. Emissions of greenhouse gases per amount of transport work are low compared to other modes. In absolute terms, greenhouse emissions from shipping are significant. Emissions of greenhouse gases from sea shipping are rising due to the increase in the global trading of goods. Currently, fuel originating greenhouse gases from shipping are not subject to any policy measures. On the other hand, sea shipping is an important source of air pollutants. Especially in coastal areas and harbours with heavy traffic, the contribution of shipping emissions to air pollution is substantial.
IMO measures include the reduction of greenhouse gas emissions from ships through the concept of evaluation (Energy Efficiency Design Index - EEDI), monitoring and improving ship performance, due to various factors that can contribute to CO_2 emissions (Ship Energy Efficiency Management Plan - SEEMP). As already acknowledged by the Kyoto Protocol, CO_2 emissions from international shipping cannot be attributed to any particular national economy due to its global activities and complex operation. Therefore, IMO has been energetically pursuing the limitation and reduction of greenhouse gas (GHG) emissions from international shipping, in recognition of the magnitude of the climate change challenge and the intense focus on this topic. The EU countries have committed to the Kyoto agreement that by 2020, the year fix energy efficiency by 20%, to settle 20% of the needs of energy consumption from renewable energy sources and reduce greenhouse gas emissions by 20%. This commitment has an impact on the legal and technical regulations associated with maritime transport. The role of the international harbour and passenger terminals in the global trade of goods and passengers is of increasing importance, especially when it recorded a significant increase in freight transport (in tonnes) transported by sea (Image1). Because of the increased maritime traffic in particle emissions from the combustion of fossil fuels, including emissions of greenhouse gases, especially carbon dioxide emissions from ships is increasing, which leads to climate change and environmental pollution. Therefore, the measures initiated on the discharge of CO_2 into the atmosphere by the IMO (International Maritime Organization) through Annex VI of the MARPOL Convention (IMO, Annex VI

Prevention of air pollution from ships 2005). The amendments to Annex VI of MARPOL includes a new chapter fourth introducing guidelines for improving the energy efficiency of ships using the design and operational measures, which should result in reduced emissions of particulate matter generated by burning fossil fuels, including greenhouse gas emissions. Changes relating to the obligation of inclusion rules for determining and controlling energy efficiency in national rules registers which prescribes mandatory application, Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) that contribute to monitoring and improving the performance of ships, monitoring and improving characteristics ship, considering various factors which may contribute to CO_2 emission.

2 The Possibility to Reduce Greenhouse Gases

Looking at the long term, depending on technological development, maritime industry will succeed in reducing greenhouse gas emissions although today still sign contracts for the construction of ships "older design" where no account is taken of the need for the reduction of emissions (Nielsen & Schack, 2012), or about fuel economy. However, there are more shipping companies and operators who have shown interest in new technologies, whether it's about investment, research and implementation of the system. It is the development of marine fleet, according to Image 1 indicates the importance of investing maritime industry and others who follow, in new technologies. Starting from the research, innovation and presentation of ideas, the development of mathematical models of making computer programs and algorithms, prototypes and their tests on ships and the training and transfer of knowledge and skills and information available, can be achieved given target. Interest areas that are directed action are complex machine, propulsion, action in service and logistics in maritime transport. Although today the maritime industry energy efficient, further advances in the technology of building the hull, engines, systems using reactive thermal energy, improve the propeller and rudder, optimization gauze and ship speed, arrival time at a particular navigable route, the analysis of the characteristics of the ship will provide lower fuel consumption as contributes to reducing emissions. Better operational measures (higher speed control travel) will also contribute to reducing fuel consumption and will be in accordance with SEEMP infection. Shipping companies have a valid reason for reducing fuel consumption, which contributes to the reduction of CO_2. The reason is the price of fuel, which represents a significant portion of operating costs in the last five years that the cost has increased by about 300%. Reducing greenhouse gas emissions, especially CO_2 reduction can be achieved by environmentally friendly system of fossil fuels, application of hybrid systems and systems without fossil fuels (Florentinus & all, 2011).



	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Container	102	152	234	371	598	969	1 076	1 193	1 249	1 127	1 280	1 393	1 445	1 524
Other dry cargo	1 123	819	1 031	1 125	1 928	2 009	2 112	2 141	2 173	2 004	2 022	2 112	2 169	2 260
Five major bulks	608	900	988	1 105	1 295	1 709	1 814	1 953	2 065	2 085	2 335	2 486	2 742	2 920
Oil and gas	1 871	1 459	1 755	2 050	2 163	2 422	2 698	2 747	2 742	2 642	2 772	2 794	2 841	2 844

Image 1: International seaborne trade, selected years (Millions of tons loaded)
Source: http://unctad.org/en/PublicationsLibrary/rmt2014_en.pdf

2.1 Hybrid system on the ship

There are many combinations of hybrid systems (Krčum et al. 2010). A hybrid power system essentially consists of two main components, showed on Image 2, the power production unit(s) or prime movers and the energy storage unit(s). The basic philosophy of the hybrid system is that the power produced can either be used to satisfy the power demand of the consumers or intermittently stored in the energy storage unit and inversely.

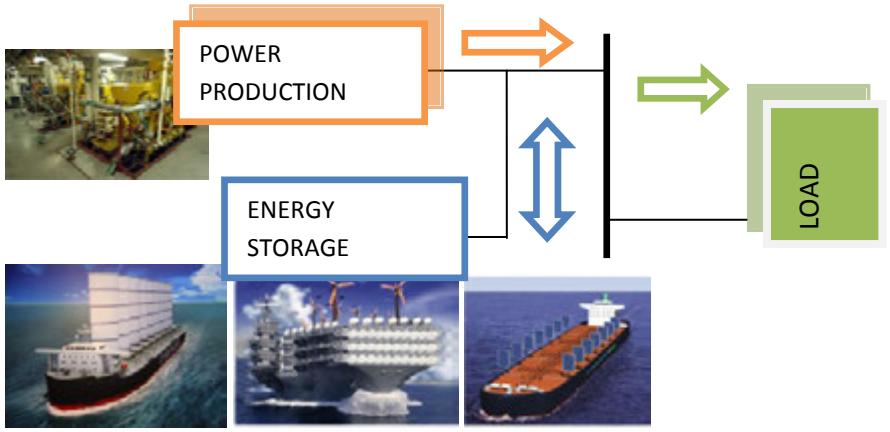


Image 2: Hybrid power system

Effective way hybrid marine power plants are wind turbines and solar panels. This is a simple 'plug and play' option concept DC energy networks. Solar panels, which transform solar

energy to electrical, are practical and ideal for battery charging. Production of electricity and energy solar panels or their photovoltaic module is roughly proportional to the intensity of sunlight. Production of electricity modules and operating voltage for a certain light intensity is determined by the load characteristics. Wind turbines and solar panels can be arranged in different ways on different types of ships for the exploitation of wind and solar energy that the sea is plentiful. Type determines the best layout for maximum use of available energy.

This paper discusses one such concept where the purpose was to optimize the operation of the ship's electrical switchboard ship-catamaran which should sail from coast-land on the Adriatic coast, using different energy sources for navigation, maneuvering or staying in the harbor.

2.2 Colored Petri Nets (CPNs) Model

Colored Petri Nets (CPN) are based on extensions to normal Petri nets (CPN Tools). Since PN simulates all of the system states and all transition judgments by token passing in a quite straightforward manner, the graphical representation for a moderate system shows very complex configuration. In CPN a place node owns several colors to represent different states and base on the colors the judgment functions in a transition node checks the states of the incoming place nodes. The characteristics dramatically simplify the graphical representation of the traditional PN and improve the execution efficiency too.

Complete multi-layer model of the EMS which contains five kinds of agents as defined in the following. They are Photovoltaic array agents (PVAgent), Battery agents (BAgent), Power grid agent (GAgent), Load agent (LAgent) and AC generator agent (ACAgent).

In the MAS, some potential conflicts among agents would be produced by the concurrency and non-determinism of the process, which leads to out of order of the whole system. PNs can improve the model of the system by having a more tidy and clear graphical representation from which, the entities in the distributed generation system are contained in different physical layers with the MAS as the energy management layer and the communication layers responsible to take care of the information flow between the physical layer (agents) and the energy management layer. It will be coded by programs and functions through a communication link between the physical layer and the energy management layer.

3 Experimetal model

According to the climatic condition, the state of charge of the battery bank and the load variation, during the operation of the hybrid system four different operation modes may appear:

Stand alone mode: In this mode there is no sufficient solar power needed by the load and the state of charge (*soc*) of the battery is also very low. All sources are disconnected from the grid and the whole load will be supplied by the AC generator. This mode avoids damages.

Battery Mode: The total current from renewable energy source is less than the current needed by the load, the energy deficit is covered by the battery bank and the controller puts the battery in the discharge condition. If the storage cannot supply the whole, the rest will be supplied by the AC generator.

Normal Mode: For this mode the photovoltaic panels produce the electric power more or equal than power references of the grid and the batteries are available. All sources are connected to the grid and the inverter delivers the electric power to meet grid power references. If the total current generated by the renewable energy is greater than the current

needed by the load, the energy surplus is stored in the batteries and the controller puts the battery in charge condition. If the produced electric power from PV panels is less than power references of the grid, the batteries can be used to compensate this difference. In the case of lack of energy during 1 hour the energy is obtained either from the batteries or from the AC generator.

Limitation Mode3: In this mode the available power from the photovoltaic panels (*Ppv*) is more than the required (P_{1gen}) and the batteries are fully charged. This condition is gathered as:

$$Ppv > P_{1gen} \text{ AND } soc >= SOCmax \quad (1)$$

The making decision of operating modes and the commutations between the modes have been modeled with colored Petri net.

In general, the five kinds of agents defined above could be simplified into two groups according their role as power supplier or power customer. Obviously, PVAgent and ACAgent are power suppliers and the LA is power customer. The BA is power supplier or power customer corresponding to discharging state or charging state respectively. Assuming that there are one set of PV generators, l set of batteries and k sets of load the color sets and variables are designed and illustrated as shown in the table 1. The battery is added to the model with two kinds of role, supplier and customer.

By combining the MAS framework, algorithms and rules in CPNs, the CPNs model for the MAS is designed as the CPN tools (Version 4.0.0) shown in Image 3. By considering the specific network topology and system loading in proposed power systems, in this paper the model just focuses on the logistics issues for implementation renewable sources for efficient shipping and communication between agents.

Places contain a set of markers called tokens. In contrast to low-level Petri nets (such as Place/Transition Nets), each of these tokens carries a data value, which belongs to a given type. As an example, place BAgent has one token in the initial state. The token value belongs to the type SOC and represents states of charge for batteries. The detail description of all colors is shown on the Image 3. The description of all the places and transitions are illustrated in Table 1 and Table 2 respectively.

BAgent represents knowledge database which consists the state of charge and initially it is assumed that batteries are fully charged. The agent learns from rules (UpdBat0, UpdBat1, UpdBat2, UpdBat3 and saves a new state in the database.

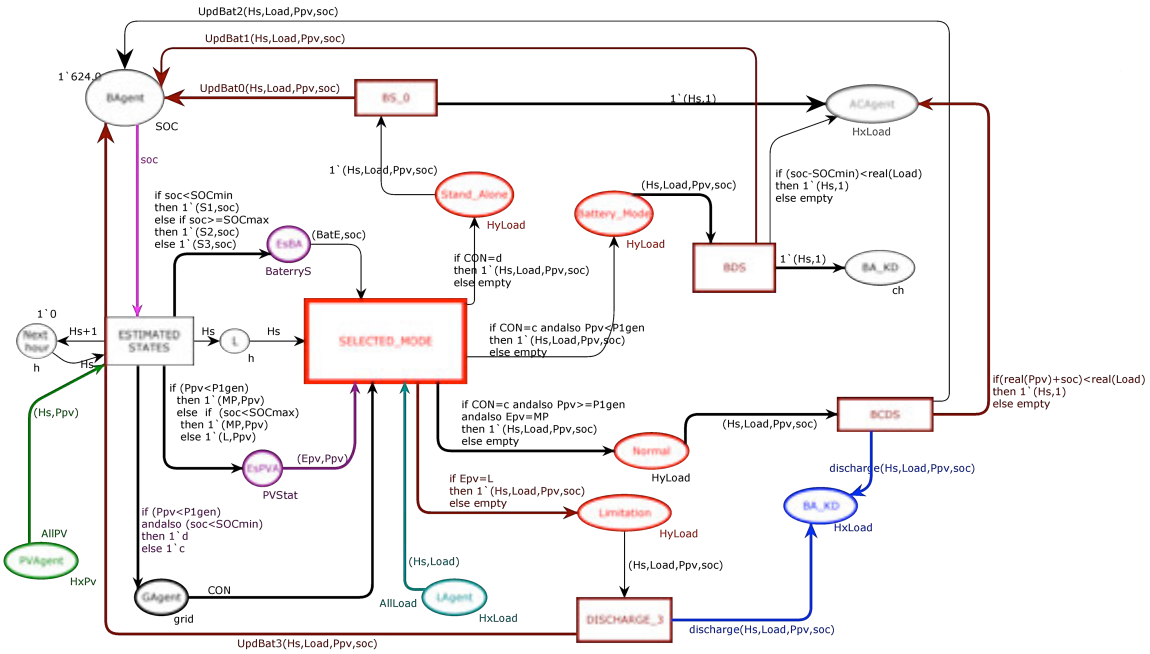


Image 3: CPN model of the ship hybrid energy system

Image 4: define

Places	Descript
BAgent	Battery A
PVAgen	PV Agen
GAgen	Grid Agent Knowladge Database
LA	Load Agent Database
ACAgent	AC generator agent Knowladge Datab
EsBA	This place is the agent confirm the estimated states for batteries
BA_KD	Battery Agent Knowledge DataBase
EsPVA	This place is the agent confirm in which mode PV is working

Stand_Alone, Battery_Mode Normal, Limitation	These places represent selecting mode of the power station

Table 1: The Meaning of places in CPN

Transitions	Description
ESTIMATED_STATES	The PDP inform all the LAF that new organization is required.
SELECTED_MODE	The Main controller makes the global supply plan and it switches from one mode to another according to the climate condition, the state of charge of the battery and the load. It communicates to the agents and tells them the corresponding entities on their new task and announces that the new organization begins.
BS_0, BDS, BCDS	Battery Strategy about Charging or Discharging. According to the SOC of battery, make a local plan about charge and discharge.
Discharge_3	The battery agents learn and save the rules to the knowledge database.

Table 2: The transitions and their description

The place *EsBA* is used to model the agent which confirms the estimated state of batteries. Three states for the batteries are considered and they are defined by three token colors (S1, S2, S3) from colors set *batStates* (see the declaration in Table 1).
For the first color (S1), the battery is empty and this state is reached when its state of charge becomes equal or inferior to a minimum value (*SOCmin*). This condition is expressed as:

$$soc <= SOCmin, \quad (3)$$

where *soc* is the estimated value of the state of charge.
For the second color (S2), the battery is fully charged and this state is reached when its SOC becomes equal or higher to a maximum value (Lu D & all 2010)0:

$$soc >= SOCmax. \quad (4)$$

For the third color (S3), the battery is in an intermediate state if remaining conditions are satisfied:

$$SOCmax < \text{soc} < SOCmax. \quad (5)$$

The place PVAgent on Image 3 is used to model database of solar power from photovoltaic panels. Photovoltaic panels can work in the well-known maximum power point tracking (MPPT) mode or in a power limitation mode (colour L) when more power are available than required by the loads. In CPN model working mode is defined as color set *PVstates*.
The place GAgent is the agent which confirms the plan about the connection sources in to the grid. Two states have been defined. The first state (color *d* on Image 3) corresponds to the disconnection of the renewable sources from the grid. When the PV production is smaller than the required grid power and the batteries are fully discharged, the priority is given to charge the storage units in order to make available as soon as possible the power station in a safety operation.

The second state (color *c*) corresponds to the connection of the renewable sources in the grid. Hence the grid operator uses estimated states of each source.

The second part of presented CPN selects operating modes of the power station. The transition SELECTED_MODE is the controller and its aim is to switch from one mode to another according to the climate condition, the state of charge of the battery and the load. When this layer receives the information from the agents EsBA, EsPVA and GAgent, the transport layer selects the next node as aforementioned mode. Each mode is represented by a single place: *Stand_Alone, Battery_Mode, Normal* and *Limitation mode*. The transition SELECTED_MODE is enabled for all modes, but it can only occur for one mode at a. This situation is called a *conflict* (because the binding elements are individually enabled, but not concurrently enabled) - and we say that the transition SELECTED_MODE is in *conflict with itself*. The switching between the modes is determined by evaluating the corresponding arc expression given according to the rules described in Table 3 and in presented CPN these rules are defined as arc functions to places *Stand_Alone, Battery_Mode, Normal* and *Limitation mode*. As it can be seen, the multi-set depends upon the kind of sources involved from application layer.

Conditions			*Selected mode*
Solar Panels	**Ebat**	**Grid**	
Ppv>P1gen	S1	d	Stand_Alone
Ppv<P1gen	S3 or S2	c	Battery_Mode
Ppv>=P1gen	S3	c	Normal
Ppv>P1gen	S2	c	Limitation

Table 3: Conditions for the selection of an operating mode

Each of the four *BS_0, BDS, BCDS, Discharge_*3 together with the surrounding arc inscriptions represent the rules from which Battery agent learns how resources are reserved and released.

4 Conclusion

Development and adoption of reliable source of renewable energy nowadays has become a major challenge to the most country of the world. That is also a big challenge for the ship industry. The shipping industry is focusing on a future based on sustainable, clean energy. Renewable energy sources, such as wind, solar energy, may have their place in helping, such as lighting on board. Fuel cells may be a possibility for new ships in the very long term, although there are currently limited in range offer a variable solution. In longer term, depending on technological developments which at the moment cannot be fully anticipated, the industry be possible to deliver more reductions emission.

With this paper authors give a small contribution to the possibility of design of new ships in according of regulations by IMO.

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Use of Social Media in Slovenian Enterprises

Marjeta Marolt
University of Maribor, Faculty of Organizational Sciences, Slovenia
marjeta.marolt@fov.uni-mb.si

Andreja Pucihar
University of Maribor, Faculty of Organizational Sciences, Slovenia
andreja.pucihar@fov.uni-mb.si

Gregor Lenart
University of Maribor, Faculty of Organizational Sciences, Slovenia
gregor.lenart@fov.uni-mb.si

Abstract

Social media offers many potential to enterprises to explore new market opportunities by providing an effective means to support communication between involved parties. The quick evolution of social media and constantly emergence of new ones makes it difficult for enterprises to choose most appropriate social media for specific purposes. Although some companies in Slovenia are present in most popular social networks (e.g. Facebook and Linkedin, etc…), and some use microblogs (e.g. Twitter) and content sharing websites (like YouTube, Flickr, etc …), and wikis for knowledge generation and sharing, many of them are still not aware of full potential of social media. In the paper we investigate potential, benefits and threats of social media usage for enterprises. In addition, based on open data from National Statistical Office, we present the status of social media usage among Slovenian enterprises. Based on results we provide recommendations for more efficient and effective use of social media for enterprises.

Keywords: social media, use, business, enterprises

1 Introduction

In the past two decades social media (SM) have dramatically changed the ways people communicate to each other and have the potential to change the ways companies do business (McAfee, 2006). The involvement of social media technologies in enterprise practices has been labeled as Enterprise 2.0. This signify the new ways of how employees, suppliers, partners, customers and other stakeholders can effectively communicate, collaborate, share knowledge and innovate (McNamee, Schoch, Oelschlaeger, & Huskey, 2010). Due to the quick evolution of SM and constant emergence of new ones makes difficult for enterprises to choose the most appropriate SM applications for specific purposes. Namely, only appropriate selection and usage of SM applications can gain competitive advantages, and develop new business opportunities (Kaplan & Haenlein, 2010; McAfee, 2006).

There are many definitions of SM, from more technological to more content-focused definitions. SM may be defined as: "Social Media is a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content" (Kaplan & Haenlein, 2010). Different authors also use different categorizations of SM. Perhaps the most known categorization of SM is proposed by Kaplan & Haenlein (2010). They argue that there is no systematic way of categorizing social media, still they tried to differentiate them in six categories: blogs, social networking sites, virtual social worlds, collaborative projects, content communities and virtual game words (Kaplan & Haenlein, 2010). Furthermore, there are two types of social media: public and enterprise wide. Public sites are usually free, available for general public and are accessed via the internet, while enterprise sites are meant for the use of the employees and are generally accessed via an intranet (Wang & Kobsa, 2009). Some forms of social media (eg. blog, wiki, podcast, media sharing, RSS, social bookmarking, social networks) can be available as public or enterprise wide (Postman, 2009).

SM was initially targeted at individuals. Only in the past decade enterprises have started using SM tools for various business purposes. Many SM tools are used for communication and collaboration purposes (Lai & Turban, 2008). Another group of SM tools enables community building and access to experts (McAfee, 2009). SM tools also support employees' social interactions which according to Molina-Morales & Martínez-Fernández (2010) lead to enterprise's ability to innovate. Additionally, SM tools have abilities to facilitate collaborative knowledge building and the effective transfer of knowledge (Kim, Jeong, & Lee, 2010; McAfee, 2009; McNamee et al., 2010). Furthermore they have abilities to provide enterprises with additional channels for marketing and customer relationship management (Wilson, 2009). Last but not least social media are also used for recruiting purposes as well as for assimilating and retaining new employees (Kim et al., 2010).

According to Kietzmann, Hermkens, McCarthy, & Silvestre (2011) there is a rich and diverse ecology of SM sites, which vary in terms of their scope and functionality. To choose the right SM site for specific purposes in such a diverse ecology of SM sites presents a challenge for many enterprises.

Since SM enables many potentials to enterprises, including increase of brand awareness, access to information, dialogue with customers and employees (Postman, 2009). Some of enterprises are aggressively adopting social media technologies for business purposes (Kiron, Palmer, Nguyen Phillips, & Berkman, 2013). On the other hand, many others are still exploring the possibilities or are even not aware of business potentials of proper and strategic use of social media.

To address these challenges this article tries to systematically present overview of social media tools and specific business purposes where those SM can be used. Additionally, current usage of SM in enterprises in Slovenia will be presented based on open data of National Statistical Office in Slovenia (SURS, 2015). In addition we provide recommendation towards the successful use of SM for business purposes.

2 Usage of social media for specific purposes

In our opinion, to better select appropriate SM for specific purpose, enterprise need to have an overview of the rich and diverse ecology of social media sites and should know for what purposes social media can be used in enterprise. Following this, first the classification of social media will be presented and second specific usage of social media in enterprise identified in practice and in academic literature will be summarized.

2.1 Classification of social media

According to Kaplan & Haenlein (2010) systematic classification of social media is impossible, as new social media constantly appear. Nevertheless they categorized social media into the six categories. Merging and extending their categorization with additional types of social media identified in practice we propose the differentiation between the following types:

- Collaborative projects are a type of SM allowing users to work together to create online content (e.g. wikis, social bookmarking applications such as Delicious, aggregators such as Pinterest)
- Blogs are special types of websites that could be compared to a personal webpage and are usually managed by single person, allowing other people to express an opinion through comments.
- Content communities are types of websites that enable users to share different types of media, such as photos (e.g. Flickr), videos (e.g. YouTube), presentations (e.g. Slideshare) and others.
- Social and professional networking sites are very popular types of websites that make it possible for people to create profile (including company's profile), connect with others, share information, comment on others' posts, user ratings (e.g. Facebook, LinkedIn).
- Microblogging are types of sites that support exchanging brief entries in a form of short text messages or media (videos, pictures and sounds).
- Location-based social networking sites are types of innovations that allow users to check-in to various locations, locate people and places or read user ratings and suggestions (e.g. Foursquare).
- Virtual worlds and online games are types of media that allows its users to interact in a three-dimensional simulated environment (e.g. World of Warcraft, Second Life)

2.2 Usage of social media in enterprises

Enterprises are using SM for different purposes. To fully exploit potentials of SM, it is important to understand how SM can be used (Vuori, 2012) it is important to understand how SM can be used to fully exploit. Therefore this chapter summarizes the social media usage identified from literature and practice review.

Many SM tools are utilized to effectively communicate and collaborate with employees, partners, customers and suppliers (Kim et al., 2010). For instance social networking sites enable sharing of information, knowledge and ideas among communities of users (Coyle & Vaughn, 2008). Blogs provide an opportunity for management to share stories and information with employees (Postman, 2009). According to (Wyld, 2008) blogs enable more spontaneous channel that support dialogue between employees and managers. Furthermore there are several wiki tools and word processing tools available online that allow collaboration among employees, customers, partners, suppliers and industry experts while maintaining versions and access control of collaborative content generation. According to Molina-Morales & Martínez-Fernández (2010) social interactions among employees are positively related to enterprise innovation. Furthermore, SM support involvement of customers to shorten the process of product development. Additionally, SM enable involvement of other stakeholder to get new creative ideas and solutions. Last but not least

enterprises can use microblogging, RSS feeds and podcasts to notify users when web sites, blogs or other online tools have been updated.

Another area where SM tools are used extensively is community building and professional networking. Currently popular social networking site that support community building and access to experts is LinkedIn. Use of other social networking sites and blogs also contribute to community building.

Furthermore, SM present promising tools for knowledge management (Levy, 2009). Namely they have ability to exploit social connections, alleviate knowledge building and transfer of knowledge (Kim et al., 2010; McAfee, 2009; McNamee et al., 2010). As effective SM tools are wikis, blogs and social networking sites (Razmerita, Kirchner, & Sudzina, 2009).

Formal learning in enterprises can also be supported by SM. According to Glowatz & Bofin (2014) SM enhance learning and students' or employees' engagement. Enterprises are beginning to use SM in combination with traditional web-based training to enrich the learning content. They usually use the combination of SM tools, including social networking sites, content communities and also blogs.

According to Kiron et al. (2013) SM is also extensively used in marketing, sales and customer relationship management. Enterprises are using a variety of SM tools for these purposes. For example, blogs help consumers to discover and get answers about specific product or service. They can also reduce the burden of aftersales activities, especially customer service. Microblogging can be very useful in creating buzz, announcing offers and events while social networking sites can be used for establishing and enhancing brand image (Agnihotri, Kothandaraman, Kashyap, & Singh, 2012). Very popular are also location-based social networking sites that enable enterprises to determine customers in the area or read their ratings and suggestions. Furthermore, enterprises are also using content communities, for instance to provide presentations of their products or services through YouTube. Last but not least some enterprises are exploiting online games for marketing purposes.

Additionally, SM can support recruiting, assimilation and employee retention. Through social networking sites enterprises can post available job positions and search for additional information about candidates (Wilson, 2009). Usage of SM, e.g. blogs, wikis can shorten the assimilation process. Namely new employee can use SM to obtain useful information that helps them faster integration into enterprise culture. Allowing the use of SM, especially internal social networking sites, also contribute to employee retention (Koch, Gonzalez, & Leidner, 2012).

3 Current usage of social media in Slovenian enterprises

In this chapter we present the status of SM usage in enterprises in Slovenia based on open data of National Statistical Office for the year 2013 (Table 1).

Survey has been done in 7.720 micro, 5.343 small, 1.144 medium-sized and 220 large enterprises. 24% of micro, 34% of small, 42% of medium-sized and 65% of large enterprises are using SM. Similar percentage of enterprises has a user profile on social networks (micro 23%, small enterprises 31%, medium-sized 38%, large enterprises 60%). More than half of micro enterprises (57%), 76% of small, and majority of medium-sized (92%) and large enterprises (99%) own a website. Only 12% of micro, 18% of small, 25% of medium-sized and 45% of large enterprises provide a link to SM profile on their website.

The less used SM are Wiki based knowledge sharing tools, as only 1% of micro and small enterprises, 2% of medium-sized and 10% of large enterprises 10% have a user profile on such a websites. Only 3% of micro, 6% of small, 12% of medium-sized and 25% of large organizations have a blog or a profile on microblogs.

Enterprises use SM mainly for enterprise's image development and marketing of products and services (micro 3%, small enterprises 6%, medium-sized 12%, large enterprises 25%), following with customer communications, e.g. responding to customers opinions, reviews and questions (micro 10%, small enterprises 15%, medium-sized 18%, large enterprises 42%).

Lower percentage of organizations use SM for involving customers in development or innovation of goods or services, for collaboration with business partners (e.g. suppliers) or other organizations, for recruitment, employment of new employees, for exchanging views, opinions or knowledge within the enterprise in lower extent (Table 1).

Only 4% of micro, 7% of small, 9% of medium-sized and 24% of large enterprises have defined formal policy for SM use (social media strategy).

Table 1: SM usage in enterprises in Slovenia in the year 2013 (SURS, 2015)

Size of enterprise Usage in %	5–9 employees	10–49 employees	50–249 employees	250 or more employees	5+ employees	10+ employees
Enterprises using SM	24	34	42	65	30	36
Enterprises with user profile on social networks	23	31	38	60	28	33
Enterprises have a blog or a profile on microblogs	3	6	12	25	5	7
Enterprises with user profile on multimedia content sharing websites	5	11	19	33	9	13
Enterprises using Wiki based knowledge sharing tools	1	1	2	10	1	2
The usage of SM for development of the enterprise's image, marketing products, services offered	18	28	34	57	24	30
The usage of SM for obtaining or responding to customers opinions, reviews, questions	10	15	18	42	13	17

4 Recommendations for Slovenian enterprises

The use of SM in enterprise cannot succeed without proper governance and SM guidelines or on a broader context SM strategy instructing how employees need to act while using SM for business purposes. Enterprises need to have knowledge and skills to monitor, identify and accordingly respond, especially to negative word-of-mouth feedback and comments. To effectively manage SM, an enterprise can outsource their SM activities, have a SM

department or a SM manager (Montalvo, 2011). Furthermore, if enterprises have an interest in integrating SM with legacy systems, they also need necessary technical expertise or they need to hire an outside expert.

When enterprises decide to utilize SM they first need to choose the right combination of SM tools. Enterprises should identify where their customers are present and understand other critical elements of the SM landscape, such as SM activities of their competitors (Kietzmann et al., 2011). When the most suitable combination of SM tools is identified, enterprises should develop a SM strategy that will be consistent and aligned with their marketing and business strategy. Next, enterprises need to prepare SM policies and guidelines on how to use SM in an enterprise context. Additionally, they need to consider which SM management tool they will use. There are many SM management tools available that manage engagement, listening, analytics and collaboration. Some of the tools are freely available, in addition there are many available with wide range of functionalities for a reasonable price.

SM is all about the content. If enterprises are using SM, they need to regularly provide new content to engage with the audience, especially existing and potential customers. The content need to appeal to the audience and this can be achieved through listening to them.

5 Conclusions

Reports from different consulting and research companies over the past year show that enterprises increasingly adopt SM. SM bring benefits to all segments of the business. The use of expertise and information gained from social networks helps to optimize the effectiveness of employees. In addition, use of SM enhance the quality and speed up business processes as well as enable to expand business boundaries to achieve greater compliance with the requirements of the client and ensure that the product or a service is developed according to customers' needs and may faster reach the market. At the same time the use of SM encourages customer involvement and increases their loyalty as well as reduces operational costs.

Social media is used by 37 percent of enterprises with at least 10 employees in Slovenia. Only 21% of enterprises publish a link to SNS (as for example Facebook, Twitter, YouTube etc …) on their website. Enterprises in Slovenia use SM primarily for communication purposes e.g. networking, creation and sharing of information with customers, partners or employees of the company. Among small enterprises there are 35% of SM users, while among medium-sized enterprises there 42% of SM users. The highest proportion of users is among large companies – 65%.

Majority of enterprises that are using SM are service based. SM are used by 47% of service based enterprises. On the other hand only 26% of production based enterprises are using SM.

One third of enterprises have a user profile on SM. Enterprises mostly use social networking sites (34%) (e.g. Facebook, LinkedIn, Google+, etc …). Among those 60% are large, 38% are medium-sized and 32% are small enterprises. 13 % of enterprises have user profile on multimedia content sharing websites (e.g. YouTube, Flickr, Picasa, SlideShare, etc …). Only 85 of enterprises use blogs or microblogs (Twitter).

Wiki based knowledge sharing tools are used only by 2% of enterprises, mainly those tools are used by large enterprises (11%).

Enterprises are using SM mainly for marketing purposes, more specifically for development of the enterprise's image and marketing of products and services offered (30%). In addition, SM are used for obtaining or responding to customers opinions, reviews and questions (17% of enterprises). Only 9% of enterprises use SM for involving customers in development or innovation processes of goods or services. Similar percentage of enterprises is using SM for recruitment and employment of new employees (8%) and for exchanging views, opinions or knowledge within enterprise (7%).

Implemented SM strategy is a baseline for proper SM utilization. However, only 9% of enterprises have implemented formal SM strategy (24% of large, 10% of medium-sized and 8% of small enterprises).

We note that only smallest proportion of micro enterprises has implemented websites, and therefore due to affordability and ease of use of SM may present opportunities for them to engage with their customers.

With utilization of SM enterprises increasingly listen to customers' opinions about their products, services and brands. Any information obtained from conversations on SM can be strategically used for business decisions, even for generation of new business opportunities as for example with new product or service development.

In Slovenia, we may notice that SM is still in its early phase of adoption. Enterprises are mostly using SM for commercial purposes and without implemented strategy. However, due to many opportunities of SM, we may expect growth of SM utilization among enterprises in Slovenia in next years. Special attention will have to be put on definition of SM strategy, which has to be aligned with business strategy. In addition, clear guidelines and roles of individuals, who will maintain enterprise communication through SM has to be defined. Proper training and awareness creation champagne has to be organized within a company to promote SM utilization and to clearly define communication rules, roles and behavior of employees. It is also important that enterprise select a proper SM to reach and address different customers and stakeholders.

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Selection of the Project Consultants Based on DEA Efficiency

Nataša Martinović
SAP West Balkans d.o.o. Belgrade, Serbia
natasa.martinovic@sap.com

Gordana Savić
University of Belgrade, Faculty of Organizational Sciences, Serbia
gordana.savic@fon.bg.ac.rs

Abstract

This paper proposes the modified Data Envelopment Analysis (DEA) model for consultant efficiency evaluation and selection. In practice, a number of criteria are used for measuring the consultant performance and their selecting for the particular project. The selection would be easier if it is based on one single performance measure, such as DEA efficiency. The main issue is how to take into consideration all relevant input and output criteria for efficiency assessment in the case of small number of the consultants, without compromising the validity of the results. For that purpose, nonlinear DEA model is created by including XOR type of constraints for particular pairs of criteria, for which significant correlation is determined. The basic DEA model is extended by these constraints due to a more precise evaluation of efficiency of consultants, to enable making better selection of the efficient consultants. Research indicates that it is possible to increase the discriminatory power of the method by reducing the number of criteria, by choosing one or the other criterion, and at the same time show it is possible to evaluate a few consultant according to a number of criteria.

Keywords: Efficiency - Data Envelopment Analysis (DEA) – ERP projects (ERP) - Consultant evaluation – Consultant selection.

1 Introduction

This study assesses the performance of each consultant in order to determine an optimal selection and engagement of consultants needed to implement projects and contribute to the company's success. The success of a project depends on a suitable and qualified project team as well as other critical factors (Hadad, Keren, and Laslo, 2013). Consultants should be assigned to a project so as to achieve maximum efficiency in project implementation in terms of time, cost and quality. The candidates' personal records of past performance may be used as general informative measures. However, the critical point in candidate selection is the determination of the appropriate and measurable criteria. The criteria most often taken into consideration are related to the candidate's personal skills and experience in similar projects. On the other hand, the decision maker could have made an easier decision based on a single

performance measure or rank of candidates. But in a real-world situation, several different criteria should be included in the analysis. Furthermore, the criteria and the method for the calculation of performance indicators and rankings should be clearly determined and known.

The paper proposes the DEA approach for measuring consultant efficiency, as a single performance measure. The original DEA model is extended to achieve higher precision in evaluating the efficiency of consultants when using a number of relevant criteria. In practice, the list of considered criteria should be shortened to provide better discrimination between candidates. The main difficulty is making the decision on which criteria retention will not significantly affect the final assessment of performance measure. Frequently, one of the criteria with a high correlation or a criterion that is similar to the existing one is eliminated from the analysis. However, another problem is how to decide which of the two highly correlated criteria should be eliminated from the analysis. The modification of the DEA model, proposed in this paper, allows the retention of correlated pairs of criteria, and introduces the restriction of using only one criterion from the pair (which corresponds to the logical XOR operator). This way, the DMU under observation is limited to the use of only one of the highly correlated criteria which present it most favourably.

The study starts with defining the problem and specifying the characteristics that are essential for the selection process. The next sections consist of the description of proposed DEA model and its application to the consultant selection, followed by the survey of results. The conclusions and bibliography are given in the last sections.

2 DEA basics and literature review

This section gives a brief overview of the DEA basics and several applications of multi-criteria approaches to consultant selection afterwards.

Charnes, Cooper and Rhodes (1978) used economic theory and Farrell efficiency measures as a basis for developing DEA models, which have been modified and expanded over the years. Suppose we have data on the engaged inputs and produced outputs for each of the n decision making units (DMUs) and their efficiency should be evaluated. Also, the following assumption should be taken into account in the DMU selection process (Cooper, Seiford and Tone, 2000, p. 22):

- Input and output data are available for each input and output and all data values are positive;
- All data which reflect the interests of managers or analysts are involved in the analysis of efficiency;
- The general tendency is to reduce inputs and increase outputs. Index efficiency should reflect this principle;
- Units of measure for inputs and outputs do not need to have the same structure. This may include: the number of hours, workspace, money, etc.

The relative efficiency of h_k for DMU_k, is defined as the ratio of a weighted sum of its outputs (virtual output) and the weighted sum of its inputs (virtual input). Charnes-Cooper-Rhodes (CCR) ratio DEA model calculates the total technical efficiency that involves pure technical efficiency and effectiveness as a result of different business volumes. Ratios obtained as results of linear DEA models empirically identify the efficient frontier, consist of efficient DMUs. Assume that there are n DMUs, and the j^{th} DMU, produces s outputs

$(y_{1j},..,y_{rj},...,y_{sj})$ by using m inputs $(x_{1j},..,x_{ij},..,x_{mj})$. The efficiency score of the observed DMU_k is given as virtual outputs (sum of weighted outputs). The basic input-oriented CCR ratio model (Charnes et al. 1978) is as follows:

$$(\max)\, h_k = \sum_{r=1}^{s} u_r y_{rk} \tag{1}$$

s.t.

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \tag{2}$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0,\ \ j = 1,\mathrm{K}\ ,n \tag{3}$$

$$v_i \ge 0;\ i = 1,2,...,m \tag{4}$$

$$u_r \ge \varepsilon;\ \ r = 1,2,...,s \tag{5}$$

where $u_r \ge 0$, are weights assigned to the r^{th} outputs, $r = 1,\mathrm{K}\ ,s$, and $v_i \ge 0$, are weights assigned to the i^{th} inputs, $i = 1,\mathrm{K}\ ,m$ in order to assess DMU_k as efficiently as possible. This basic CCR DEA model should be solved n times, once for each DMU_k. The index h_k shows relative efficiency of DMU_k, obtained as the maximum possible achievement in comparison with the other evaluated DMUs.

A number of different variations of DEA models have also been developed. Some of them include the BCC model (Banker et al. 1984), which assumes variable return to scale; Banker and Morey (1986) model, which involves qualitative inputs and outputs; Golany and Roll (1989) model, where input-output weights are restricted to certain ranges of values. The basic DEA models allow full flexibility in choosing the weights of inputs and outputs. However, those weights can be in conflict with prior knowledge or accepted viewpoints of the relative importance of inputs and outputs. Application of DEA methods in solving real-life problems prompted the development of methods for the assessment of values. It is part of a study of efficiency evaluation that reflects preferences of decision-makers in the process. The introduction of additional restrictions for the weight or restrictions which are bases for value-assessment of inputs and outputs leads to narrowing or expanding the limits of efficiency. More about the possibilities of limiting weight and virtual inputs and outputs, as well as original solutions, can be found in (Martic, 1999) and (Sarrico and Dyson, 2004).

Most DEA applications are focused on performance evaluation, but there are several attempts to apply it on selection, either as the main method or in combination with other multi-criteria/multiatribute approaches. Some of them are given briefly in the following paragraph.

Defersha et al. (2012) propose a new mode of using DEA as a cost estimation tool based on parametric or non-parametric approaches which can be used to: provide cost estimations, generate cost estimates via parametric (statistical criteria) and non-parametric methods (artificial neural network), or rank competitive brands and models of products available in the market and help purchasers in the selection of these products. Darehmiraki and Behdani (2013) use DEA as a new ranking method, based on applying aggregate alternative and the fact that one efficient alternative with a better performance has stronger effects on the group

of the other alternative (the results of the proposed method are compared with those obtained using the TOPSIS method). Schlamp and Fecker (2002) demonstrate that DEA can be a useful tool for management consulting – DEA is used to identify potential synergy effects through mergers and acquisitions via efficiency elasticity, and requires careful analysis for a company which is in restructuring and is significantly changing resources and performance. Azadi and Farzipoor Saen (2012) developed a new chance-constrained DEA model for the selection of suppliers, which incorporated undesirable outputs and stochastic data, and considered multiple and conflicting criteria in supplier selection decisions (possible to apply in more fields). Wang and Li (2011) introduced an algorithm for candidate selection for district alliance of university incubators based on DEA. Tsai Bi-Huei (2011) explored the influence of ERP implementation on corporate performance using a modified DEA approach. They investigated how implementing ERP affects company input-output efficiency by adopting a two-stage approach: data envelopment analysis and Tobit regression. The study has been limited to monitoring the performance of companies for 6 years after ERP implementation. The results suggested that the implementation of ERP systems increased the corporate performance. Hadad, Keren and Laslo (2013) propose a decision-making support system (DMSS) module for selecting project managers and demonstrate its implementation, which is delimited to the candidates' proven performances. The DEA method (the Cross-Efficient method) meets the defined requirements. A ranking method was implemented with three inputs and four outputs selected for the project ranking.

Usually, DEA is applied following an established procedure. The first step is to define a set of DMUs, followed by the selection of inputs and outputs as criteria relevant for efficiency evaluation. But in a real-life application, the selection of the most relevant criteria is not an easy task, especially if there are pairs of criteria considered to be of similar importance. This issue will be discussed in the next sections.

3 Proposed models

This paper proposes the modified nonlinear programming DEA model for project consultant evaluation to help solve the problem of including similar criteria into the analysis. The main idea is to retain all relevant criteria in the evaluation, although there are pairs of criteria that are very similar and highly correlated. The model is developed on the basis of the well-known existing DEA models.

3.1 Modified DEA model

Based on the basic DEA model, authors proposed a modified DEA model tailored to the problem at hand. The main motivation is the real-world problem of selecting SAP consultants based on their efficiency. There are eight criteria commonly used in practice. However, in our case, the number of consultants was insufficient, which is the reason most of them were evaluated as efficient. Usually, the implementation procedure assumes selecting a particular number of the most relevant criteria. But the task can be problematic if pairs of very similar criteria exist (indicates the same feature of the consultants). The question is which criterion from the pair of similar or correlated criteria should be excluded from the analysis. To bridge this problem, authors suggest a modified DEA model with a constraint based on logical XOR operator. Actually, all criteria are preserved in the evaluation, but DMU is allowed to decide which criterion is more preferable by assigning weight greater than 0 to only one in the pair.

Since the real-world problem authors attempt to solve assumes three categories of consultants, we used the categorical DEA model (Banker and Morey 1986) as a basis for further modification. The categorical model describes the situation when some inputs and outputs can often express a characteristic and take only discrete values from a defined set of values 1,2,…,C. The value of C splits the observed set of DMU on C categories. The observed set of n DMU can be defined as $D=\{1,2,\ldots,n\} = D_1 \cup D_2 \cup \ldots \cup D_C$ where $D_a = \{i/i \in D$ for input variable $a\}$ and $D_a \cap D_b = \varnothing$. DMU $k \in D_L$, $L \in \{1,\ldots,C\}$, can be assessed in relation to the unit in the set $\bigcup_{l=1}^{L} D_l$. That means that if $k \in D_1$, DMU_k is assessed only in relation to D_1, if $k \in D_2$, DMU_k is assessed only in relation to $D_1 \cup D_2$ etc.

Let us define three sets of inputs and three sets of outputs. For DMU_k, the first set consists of m_1 inputs ($M1=\{x_{1,k}, x_{2,k}, .., x_{m_1,k}\}$), the second set consists of the following m_1 inputs ($M2=\{x_{m_1+1,k}, x_{m_1+2,k}, .., x_{2m_1,k}\}$) and third set is consist of the rest $m\text{-}2m_1$ members ($M3=\{x_{2m_1+1,k}, x_{2m_1+2,k}, .., x_{m,k}\}$). Each member of the set M1 is highly correlated with one of the members of the second set of inputs (M2). The logical XOR operator assumes that DMU should opt for only one input from the pair by weighting it. Each pair consists of one input from the set M1 and one highly correlated input from the set M2. This means the first pair consists of the first input from M1 and the first input from M2, the second pair consists of the second input from M1 and the second input from M2, etc. The pairs are $\{(x_{1,k}, x_{m_1+1,k}), (x_{2,k}, x_{m_1+2,k}), \ldots, (x_{m_1,k}, x_{m_1+m_1,k})\}$. Finally, the inputs from the third set M3 can be weighted freely by DMU under evaluation. Similarly, we introduced three sets of outputs for DMU_k: the first set of s_1 outputs ($S1=\{y_{1,k}, y_{2,k}, .., y_{s_1,k}\}$) where each member is paired with one of s_1 outputs from the second set ($S2=\{y_{s_1+1,k}, y_{s_1+2,k}, .., y_{2s_1,k}\}$) and the third set of ($s\text{-}2s_1$) outputs ($S3=\{y_{2s_1+1,k}, y_{2s_1+2,k}, .., y_{s,k}\}$) that can be freely weighted. The new model is as follows:

$$(\max)\, h_k = \sum_{r=1}^{s} u_r y_{rk} \tag{6}$$

s.t.

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \tag{7}$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \; j \in \bigcup_{l=1}^{L} D_l \tag{8}$$

$$v_i v_{m_1+i} = 0; \; i = 1,2,\ldots,m_1 \tag{9}$$

$$v_i + v_{m_1+i} \ge \varepsilon; \; i = 1,2,\ldots,m_1 \tag{10}$$

$$v_i \ge \varepsilon; \; i = 2m_1+1,\ldots,m, \tag{11}$$

$$u_r u_{s_1+r} = 0; \; r = 1,2,\ldots,s_1 \tag{12}$$

$$u_r + u_{s_1+r} \ge \varepsilon; \; r = 1,2,\ldots,s_1 \tag{13}$$

$$u_r \geq \varepsilon; \quad r = 2s_1 + 1, \ldots, s, \tag{14}$$

The categorical DMUs are separated by constraint (8). The XOR conditions described before the model are ensured by constraints (9) and (10) for weights of pairs of correlated inputs, while conditions (12) and (13) ensure XOR conditions for the pairs of correlated outputs. The model (6)-(14) is non-linear but it could easily be transformed into linear form in case that a large number of non-linear variables causes difficulties in finding an optimal solution. The pre-defined non-linear model will be solved for each DMU_k (k=1,...,n).

4 Case study: Efficiency evaluation of consultants

The assignment of the most appropriate resources/consultants to each project according to various restrictions is very important. The restrictions are expressed as criteria which have impact on the decision maker. This assignment can be completed in three ways: (1) Full engagement of internal consultants (consultants employed in main company – have the highest level of knowledge and experience), (2) Partial engagement of external consultants (partial outsourcing), and (3) Full engagement of external resources (total outsourcing). If the project has strategic importance, there is a pressing need for high quality. For such projects the third option (fully engaging external resources) is not acceptable. In this case, an internal consultant will be the selected resource because of a higher level of quality.

The word "outsourcing" here means that the company engages consultants from other partner companies, which means that the contractor (prime) engages another partner company as subcontractor for their projects. Engaging internal consultants means that consultants are directly employed by the contractor, or consultants are employed in subsidiaries and affiliated companies around the world.

4.1 Problem modelling

The problem could be defined using a four-level hierarchy, which is discussed in this section. The overall goal is to select the most suitable consultant/consultants for the selected company on contractual projects. The next two levels are criteria and sub-criteria related to costs, work experience, education and communication skills, while the DMUs are defined as alternatives (fourth level defined as consultants A, B, C, D, E and F).

In practice, the decision maker (Project Manager), in accordance with his/her professional judgment, selects an appropriate consultant taking into account the size of project, the consultant's skills (prior experience and the number of successful implementations), costs (projects are limited with available budget), project time line and availability of consultants in the particular period. Obviously, the decision maker is faced with a multi-criteria problem and the necessity to find the best solution without using an exact method.

This is the reason for choosing efficiency as the criterion of suitability of consultants in this paper. For the purpose of efficiency evaluation of consultants, the DEA method is implemented through the following steps:

1. DMU selection,
2. Defining and selection of suitable criteria,
3. Determining of Inputs and Outputs,
4. Original Raw Data Collection,

5. Correlation Analysis,
6. Grouping criteria with a high correlation,
7. DEA model application,
8. Consultant efficiency evaluation.

Alternatives in the decision-making process correspond to a set of consultants where DMUs for a given project may take the values: Consultant A, Consultant B, Consultant C, Consultant D, Consultant E and Consultant F.

In the second step it is necessary to define and select suitable criteria. The problem 'how to select the most appropriate consultant for the project' is modelled by making a decision based on the following criteria and sub criteria:

• **Cost (CO)**

- Consultancy Cost (CC): Consultancy Services Price (money/day).

• **Work experience (WE)**

- Projects Completed (PC): Defines % of the life cycle of implementation in which consultants were involved.
- References (RE): Defines the number of consultant references.
- Customer Recommendation (CR): Score of customer satisfaction with the consultant after completion of implementation in the required areas (ranging from 1to 5).
- Companies (CE): Defines source type for companies where consultants are employed (previously described as internal, partial outsourcing, full outsourcing).

• **Education level (EL)**

- Occupational Seminars (OS): Courses (training) or certification previously received by the consultant (SAP modules that are a part of the project and which the consultant can implement).

• **Communication ability (CA)**

- Awareness of Responsibility (AR): Refers to the liability of consultants in terms of their work.
- Ability to Persuade (AP): Indicates the ability of the consultant to present best practices and convince the client for a proposed solution.

The criteria are divided into sets of inputs and outputs, in accordance with the characteristics and the cost of the consultant and his results (step 3). In addition to the consultancy cost (CC) criterion, the sub-criteria: number of completed projects (PC) and number of references (RE) and completed seminars (OS) as measures of experience and education of the consultant are taken as inputs. The sub-criterion of customer recommendation (CR) and two sub-criteria of communication ability (AR and AP) are taken as outputs. Communication abilities are assessed by the decision maker based in an interview with the potential consultant. The criterion Companies (CE) is viewed as a categorical variable (values of categorical variable can be 1, 2 and 3, which define the type of consultant considered as DMU in further analysis).

The criteria and sub-criteria values of a consultant are given based on the author's experience in project implementations, interviews with other senior project managers and experience with SAP implementation in Serbian companies in the past. The given values are a simulation of the market values, due to data confidentiality. Initial values of inputs and outputs according to the assessment of the decision maker are given in Table 1 (step 4)

	Input				Output			
	CC	**PC**	**RE**	**OS**	**CR**	**AR**	**AP**	**CE**
Consultant A	560	70	2	2	3.00	Good	Average	Ext
Consultant B	650	90	2	2	3.25	Good	Very good	Ext
Consultant C	670	100	5	4	5.00	Excellent	Excellent	Int
Consultant D	600	80	2	1	3.50	Good	Good	Ext
Consultant E	690	100	4	3	4.00	Very good	Very good	Ext1
Consultant F	740	100	7	4	5.00	Excellent	Excellent	Int

Table 1: Inputs and Outputs according to decision maker evaluation

Final values of inputs and outputs, qualitative values quantified according to the Lickert scale and categorical values are shown in Table 2.

	CC	**PC**	**RE**	**OS**	**CR**	**AR**	**AP**	**CE**
Consultant A	560	70	2	2	3.00	5	3	2
Consultant B	650	90	2	2	3.25	5	7	2
Consultant C	670	100	5	4	5.00	9	9	1
Consultant D	600	80	2	1	3.50	5	5	2
Consultant E	690	100	4	3	4.00	7	7	3
Consultant F	740	100	7	4	5.00	9	9	1

Table 2: Quantification of qualitative values

In this step, several experiments have been done. An important fact is that the number of DMUs (6 consultants) is even lower than the total number of criteria (4 inputs and 3 outputs), which will lead to unrealistic results. Namely, the evaluation of efficiency of consultants by applying the basic CCR DEA model, as expected, showed a large number of efficient consultants (research includes a low number of consultants in relation to the number of criteria). For the same reason, it is not necessary to introduce categories of consultants, which has been demonstrated experimentally. The results shown in the second and third column of Table 5 implied that the efficiency after introducing categorical DMUs remained the same as the results obtained using the basic CCR DEA model. Better discrimination will be achieved by reducing the number of criteria, which will be done in the following steps.

In theory, a large number of criteria related to the number DMU decreases the discriminating power of the method and therefore the authors have done correlation analysis of the criteria (step 5). The results are shown in Table 3.

	CC	*PC*	*RE*	*OS*	*CR*	*AR*	*AP*
CC	*1*						
PC	*0.934175*	*1*					
RE	*0.863113*	*0.765466*	*1*				
OS	*0.77886*	*0.783349*	*0.906103*	*1*			
CR	*0.803831*	*0.815937*	*0.934544*	*0.883782*	*1*		
AR	*0.795961*	*0.804084*	*0.951972*	*0.951817*	*0.981694*	*1*	
AP	*0.908816*	*0.946753*	*0.800629*	*0.800499*	*0.874672*	*0.841021*	*1*

Table 3: Correlation analysis of the criteria

The results of correlation analysis showed that there is a high correlation between the criteria and it is possible to eliminate some of them from the analysis, without losing the important information about efficiency. It is difficult to decide which of the criteria should be eliminated. Therefore, the authors decided to use the rule 'Exclusive OR' Boolean algebra. In this mode, the evaluated DMU allows you to select one of the two criteria that have an exclusive relationship or the one which is more favorable to DMU. This leads to introducing the idea model (6)-(14). Additionally, the ideas are based on the approaches given in the papers by *Vayvay, Ozcan and Cruz-Cunha (2012)*, and Martinovic and Delibašić (2013). The model given in the first paper is adapted to the specific case for the selection of the most suitable consultant who will be engaged in one of the multiple concurrent projects of ERP implementation. The second paper, titled "Selection of the best consultant for SAP ERP project using combined AHP-IBA approach" used AHP method combined with Interpolative realization of Boolean algebra (to generate new criteria that include the relationship between the initial criteria instead of the case in baseline study mentioned as a., where AHP, Fuzzy AHP and ANP models are used) for consultant selection.

In the sixth step, we selected pairs of the input and output criteria with correlation coefficients greater than 0.9. The most important criteria and their interrelations, according to the results of the correlation analysis are shown in Table 4.

	Input				**Output**			
	CC ⩒ PC		**RE ⩒ OS**		**CR ⩒ AR**		**AP**	**CE**
Consultant A	560	70	2	2	3.00	5	3	2
Consultant B	650	90	2	2	3.25	5	7	2
Consultant C	670	100	5	4	5.00	9	9	1
Consultant D	600	80	2	1	3.50	5	5	2
Consultant E	690	100	4	3	4.00	7	7	3
Consultant F	740	100	7	4	5.00	9	9	1

Table 4: The criteria and their interrelations, according to the results of the correlation analysis

Obviously, the set of inputs is divided into two sets with two members (M1= {CC, RE}, M2= {PC, OS}), e.g. m_1=2, m=4 $\Rightarrow m-2m_1=0$. The set of outputs is divided into three sets with one member (S1= {CR}, S2= {AR}, S3= {AP}), e.g. s_1=1, s=3 $\Rightarrow s-2s_1=1$. This ensures that the efficiency index depends only on one criterion from the correlated pairs. In our case, the efficiency index depends on the two inputs and two outputs. The combination of inputs and outputs can be different for each DMU.

The constraints (10)-(14) specific for our non-linear model are as follows:

$$v_1 v_3 = 0; \quad v_2 v_4 = 0; \tag{9}$$

$$v_1 + v_3 \geq \varepsilon; \quad v_2 + v_4 \geq \varepsilon; \tag{10}$$

$$u_1 u_2 = 0; \tag{12}$$

$$u_1 + u_2 \geq \varepsilon; \tag{13}$$

$$u_3 \geq \varepsilon; \tag{14}$$

The value of ε is set to 0.001. The model (6)-(14), with six nonlinear and one linear variable and fourteen constraints at most, should be solved 6 times (once for each DMU). Considering the dimensions, the model is not too big and a global solution can be reached by conventional solvers with no transformation into liner model.

5 Results and discussion

From experience and based on the performed correlation analysis of criteria, the authors have conducted different experiments with results given in Table 5. As in the aforementioned, the first set of experiments is performed in order to make a basic efficiency evaluation using model (1-5) and categorical DEA model (6-8) with no XOR rules. The efficiency indexes are given in columns 2 and 3 of Table 5. The second set of experiments assumes only one XOR rule (RE $\underline{\vee}$ OS). The results are shown in columns 4 and 5. Finally, a set of experiments includes all three XOR rules mentioned previously. The results are given in the last two columns of Table 5.

DMU	h_k^*	h_k^* *Categorical*	h_k^* RE $\underline{\vee}$ OS	h_k^* RE $\underline{\vee}$ OS *Categorical*	h_k^* RE $\underline{\vee}$ OS, CC $\underline{\vee}$ PC, CR $\underline{\vee}$ AR	h_k^* RE $\underline{\vee}$ OS, CC $\underline{\vee}$ PC, CR $\underline{\vee}$ AR *Categorical*
A	1.000	1.000	1.000	1.000	**0.841**	**0.841**
B	1.000	1.000	1.000	1.000	1.000	1.000
C	1.000	1.000	1.000	1.000	1.000	1.000
D	1.000	1.000	1.000	1.000	1.000	1.000
E	**0.892**	**0.892**	**0.892**	**0.881**	**0.846**	**0.843**
F	1.000	1.000	**0.998**	1.000	**0.904**	**0.930**

Table 5: Data and DEA analysis results

We come to a conclusion that there is a no difference between the DMUs efficiency/inefficiency assessment obtained using the basic DEA model and using the DEA model with categorical DMUs. Namely, the same consultants are assessed as inefficient in all cases. Furthermore, only one consultant E, with relatively high consultancy cost (CC) and low abilities in comparison with consultant C, is inefficient according to basic DEA models as a result of a large number of criteria.

The consultants are differentiated by including XOR rules. One XOR rule (RE $\underline{\vee}$ OS) result in inefficiency of Consultant F, since it has the same outputs as Consultant C, but the inputs are higher. Models with no XOR rules included, assessed Consultant F as efficient by ignoring inputs RE, CC and OS ($v_1 = 0, v_2 = 0.01, v_3 = 0, v_4 = 0$), which is disabled by rule RE $\underline{\vee}$ OS and weights assigned to inputs ($v_1 = 0, v_2 = 0.00993, v_3 = 0.001, v_4 = 0$) result in consultant inefficiency. Similarly, Consultant A is assessed as inefficient in the case of introducing XOR rules RE $\underline{\vee}$ OS, CC $\underline{\vee}$ PC and CR $\underline{\vee}$ AR. Obviously, consultant A became inefficient when there was a choice between two outputs CR and AR. The source of its efficiency lays in weights of 0.2084 assigned to output CR and weight of 0.0749 assigned to output AR. Table 6 gives an overview of weight assigned to inputs and outputs by the basic DEA model (1-5) and the modified DEA model (6-14) proposed in this paper. Different DMUs selected a different combination of inputs and outputs, but each efficiency index is calculated based in two inputs and two outputs.

Consultant	**Model**	Input weights				Output weights		
		CC	PC	RE	OS	CR	AR	AP
A	(1-5)	0.0000	0.0104	0.1346	0.0000	0.2084	0.0749	0.0001
	(6-14)	**0.0011**	**0.0000**	**0.0000**	**0.1998**	**0.0000**	**0.1676**	**0.0010**
B	(1-5)	0.0000	0.0097	0.0629	0.0000	0.0000	0.0000	0.1429
	(6-14)	**0.0010**	**0.0000**	**0.0000**	**0.1750**	**0.0515**	**0.0000**	**0.1189**
C	(1-5)	0.0000	0.0100	0.0000	0.0000	0.0000	0.0000	0.1111
	(6-14)	**0.0011**	**0.0000**	**0.0500**	**0.0000**	**0.0479**	**0.0000**	**0.0845**

D	(1-5)	0.0000	0.0117	0.0000	0.0650	0.2856	0.0000	0.0001
	(6-14)	**0.0012**	**0.0000**	**0.1497**	**0.0000**	**0.2070**	**0.0000**	**0.0551**
E	(1-5)	0.0005	0.0000	0.1573	0.0000	0.0000	0.1140	0.0134
	(6-14)	**0.0010**	**0.0000**	**0.0000**	**0.1033**	**0.0000**	**0.0010**	**0.1194**
F	(1-5)	0.0000	0.0100	0.0000	0.0000	0.0000	0.0000	0.1111
	(6-14)	**0.0010**	**0.0000**	**0.0000**	**0.0650**	**0.0000**	**0.1019**	**0.0014**

Table 6: Weights

For the particular project, three consultants can be selected based on their potential efficiency: Consultant B and Consultant D as partially outsourced, and Consultant C as internal consultant. This means that consultant E from third group (Ext1- total outsourcing) would not be acceptable despite of better outputs than Consultant D (partial outsourcing) mainly because of the higher consultancy cost.

This way, the basis for the decision making is set. Further analysis can be done with the model for super-efficiency evaluation in order to rank efficient consultants.

6 Conclusions

This paper aims to solve the problem of assigning consultants to projects. After interviews with other experienced project managers, the decision maker understands that the main cause of problems in the selection of consultants is the inability to choose the best consultants when there are several alternatives. The second cause lays in the selecting of the most appropriate and measurable criteria from the list. The decision maker could have made an easier decision based on a single performance measure or rank of candidates. This means that criteria should be aggregated into one measure. In this paper relative DEA efficiency is used as a performance measure.

Using the modified DEA approach, the efficiency of each consultant is evaluated based on the criteria of the project manager in relation to the selected method. The performed correlation analysis showed that some of the criteria can be eliminated. The problem is to choose which of the two criteria (with high correlation) should be excluded from the analysis. Authors conducted further research on interrelations of certain criteria and their impact on efficiency measures. A useful modification of the existing model was the assignment of a null weight to one of the two correlated criteria. This means that the inferior criterion for each consultant (compared to other consultants) will be eliminated (for each decision making unit).

A new model applied in this research showed it is possible to increase the discriminatory power of the DEA method by reducing the number of criteria with 'Exclusive OR' rules, and that at the same time it is possible to evaluate efficiency on a small sample with a number of criteria.

Authors have defined criteria and estimated the value of their relative weight based on the experience on previous projects and interviews with other project managers.

Using the modified DEA approach and performing correlation analysis, authors investigated the impact of certain criteria interactions on efficiency measures. As a result, the most acceptable are consultants whose price is not the lowest. The decision rather depends on a combination of price, experience, and recommendations of users.

Further research could perform sensitivity analysis and determine the boundaries that significantly affect the change in results.

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Stakeholder Management Approach – A Key for Successful IT Project Delivery

Mirjana Micić
University of Belgrade, Faculty of Organizational Sciences, Serbia
micic4010mo@fon.bg.ac.rs

Zorica Mitrović
University of Belgrade, Faculty of Organizational Sciences, Serbia
zorica.mitrovic@fon.bg.ac.rs

Vladimir Obradović
University of Belgrade, Faculty of Organizational Sciences, Serbia
obradovicv@fon.bg.ac.rs

Abstract

The complex and uncertain nature of IT projects require an effective stakeholder management approach to address different stakeholders' needs and emerging issues with respect to their expectations. Previous research regarding stakeholder management in IT sector in Serbia seems to be generic or even lacking. This paper analyzes different methodologies for stakeholder management and especially management of stakeholders' expectations. It was interesting to conduct survey targeting both IT project managers and purchasers in order to find out the trends in application of different stakeholders management practices and purchasers level of satisfaction with the end results. The research showed that there is a need for further and more extensive training of IT project managers to successfully manage the stakeholders' expectations. IT project managers have to understand what is expected of them; they have to know how to direct expectations in order to control delivery of the project results. On the other hand purchasers have to be educated in order to know what they can expect as project output. In the case of the IT projects in Serbia this specific aspect of project management is still underdeveloped and this paper is effort to initiate further research and recommendation for application.

Keywords: stakeholder management, IT project

1 Introduction

From the beginning of IT project development in the 60s of the last century until the end of 20th century, the criteria for IT project implementation success included spent time, total costs and delivered quality (Davis, 2014). However, practice has shown that people who have an interest in the IT project successful completion, as well as people who have an impact on the IT project performance, have a significant influence on IT project performance. For this reason, stakeholder management and managing stakeholder expectations are gaining growing attention. In addition, the number of papers dealing with this subject is increasing rapidly.

For the purpose of this paper, IT project refers to the development of different software adapted to the requirements of a particular client. Even though, there are different methodologies for the implementation of software development projects, their success rate is fairly low (Perkusich, Soares, Almeida, & Perkusich, 2015). Complexity of these projects is reflected in the number of iterations and contact frequency between the client and the IT project manager. Moreover, these frequent contacts are followed by numerous requirement changes which means that, in terms of adapting to client's needs; the flexibility level of software solutions has to be high (Liu, Chen, Chan, & Lie, 2008). On the other hand, frequent requirement changes can cause misunderstandings and conflicts between clients and IT project managers. For this reason, stakeholder management for IT projects is very significant (Missonier & Loufrani-Fedida, 2014) (Purvis, Zagenczyk, & McCray, 2014).

In Serbia, fundamental problems in this area include lack of theoretical and practical knowledge, as well as insufficient research on stakeholder management for IT projects, and other IT fields, in general. It is a well-known fact that clients are not sufficiently acquainted with the field, and that IT project managers are usually not interested in training clients and familiarizing them with the IT terminology and potential possibilities, which consequently leads to implementation time expansion and higher possibility of failure. This is also supported by the defined Strategy for information society development of the Republic of Serbia until 2020, whose first step is introducing the concept of e-business and e-commerce management training to small and medium-sized enterprises and their employees (Vlada Republike Srbije, 2010).

The goal of this paper is to come to the knowledge of the extent of the key stakeholders (clients and IT project managers) satisfaction with the results of IT projects, and also determine how successful do they consider those projects to be. In addition, role of the paper is to indicate the importance of understanding and trust among key stakeholders for the successful realization of IT projects, highlighting the question about significance of managing stakeholders and especially their expectations.

In the first section of the paper, the theoretical background for the stakeholder management and IT project success assessment will be presented. Later, paper analyzes this topic in practice using the survey conducted on the basis of interviewing IT project managers and IT project clients in the Republic of Serbia. At the end of the paper, conclusion and recommendations for future scientific research based on discussion of results are included.

2 Theoretical background

2.1 Assessment of Project Performance

According to Ahmad et al., *"it may be almost impossible to find agreement about whether the project succeeded or failed"*; this is because one group of stakeholders may see it as successfully implemented while another may perceive it as a complete failure (Lehtinen, Mäntylä, Vanhanen, Itkonen, & Lassenius, 2014).

According to the IT project manager perception, project success rate was determined, for a long period, solely using the "iron triangle" (time, cost, and quality). For this reason, in order for the project to be a success, it was necessary to determine two constants of the three before mentioned success factors while the third had to be adapted to the two pre-determined factors. However, at the turn of the century, stakeholder satisfaction and "people focus" became increasingly important for the project success (Davis, 2014). In 2004, Project Management Institute (PMI) published The PMBOK Guide – Third Edition. In that book, project success is measured by the project satisfaction of the key stakeholders and the iron triangle. Based on

the already mentioned project success criteria, Procaccino and Verner define major project success as *"project's ability to meet its operational and stakeholder objectives – with emphasis on the people side of project success factors, rather than only the iron triangle"* (Mazur, Pisarski, Chang, & Ashkanasy, 2014).

Customer competency is an important criterion for a successful project implementation (Jørgensen, 2014). From the customer point of view, six different factors influence the project: use of the final product, repeat business with the supplier, time passed between the signing of the contract and delivery of the final product, project implementation cost, quality of the final product measured by the user satisfaction and client involvement during the project implementation (Davis, 2014).

Results of the survey conducted by (Jørgensen, 2014) indicate that the client is able to reduce the risk of project failure significantly if he selects a competent supplier, rather than the low price of the project implementation. In addition, his conclusion is that the best way to select such a supplier is to analyze his project skills based on previous collaborations and failure rate of completed projects. Moreover, Nakatsu and Iacovou claim that changing the IT project manager increases the risk of misapprehension of software requirements (Savolainen & Ahonen, 2015), which could consequently exceed given time limit and, for this reason, maximize the risk for project failure. Contrary to the previous opinion, Achterkamp, Vos, Brown and Jones state that project failure in general is not the result of a project practice that is lacking or ineffective, but it arises from an improper social interaction between stakeholders (Missonier & Loufrani-Fedida, 2014).

The most common factors of project failure are: conflicts between stakeholders, communication breakdown, inadequate compensation for the overtime work, lack of skills and necessary expertise, and lack of team spirit (Lehtinen et al., 2014).

Taking all these authors into consideration, it is possible to say that there isn't any agreement about the criteria for project success assessment. However, a common perception of all authors is stakeholder engagement in project success assessment. In support of this conclusion (Lehtinen et al., 2014) considers the collaboration of individuals and organizations, in charge of different project implementation areas, paramount for the success of the project. For this reason, it is necessary to pay closer attention to the managing of the project stakeholders.

Project complexity and trust among stakeholders have a significant influence on stakeholder management and IT project performance. Hence, an explanation of these terms must be included in the paper.

Sinha indicates *"there is no single concept of complexity that can adequately capture our intuitive notion of what the word ought to mean"* (Vidal, Marle, & Bocquet, 2011). The complexity of something is usually defined as *"consisting of many varied and interrelated parts"* (Baccarini, 1996). However, this definition is so effective that it might be used for any scientific field, and not only project management. The project complexity can be defined as *"property of a project which makes it difficult to understand, foresee and keep under control its overall behavior, even when given reasonably complete information about the project system"* (Vidal, Marle, & Bocquet, 2011). In this paper, the size and complexity of IT projects will be measured using the stakeholder approach which includes the number, geographic distance, the diversity of interests and levels of intolerance between the key IT project stakeholders (Vidal, Marle, & Bocquet, 2011). From the project implementation success point of view, more complex projects require more time, expenses, energy, engagement and cooperation of project participants. For this reason, the possibility of those projects being less successful than the ones more easily manageable is much greater.

On the other hand, for an IT project to be a success, it is crucial that there be trust among the stakeholders. Davenport emphasizes that in order to secure trust among stakeholders there has to be a certain level of dependency, and they have to follow a particular set of expectations (Siew, 2014). It is easy to draw a conclusion that the lack of trust among stakeholders may result in diminished project success or even failure. Reason for this is the readiness of one stakeholder, motivated by the lack of trust in other stakeholders, to act solely in his own interest, and in doing so harming some or all other stakeholders participating in the project.

Key factors for building trust are mutual understanding of individual values of stakeholders; improved, fair, balanced and trustworthy communication; skillful facilitation and cooperation; and minimalizing of stakeholder's turnover impact (Siew, 2014). It is easy to reach a conclusion that individual level and type of knowledge may influence the trust among stakeholders. With regard to IT projects, Reich emphasizes that three basic types of knowledge include technical design knowledge, business value knowledge, and organizational change knowledge (Savolainen & Ahonen, 2015). In accordance with that, Gray indicates that if the level and type of knowledge of one stakeholder does not correspond with the level and type of knowledge of others, than the potential disconnect of these two "knowledge systems" may diminish their mutual trust (Siew, 2014).

Considering that the trust among stakeholders is significant for a successful project implementation, it is quite evident that the diminished level or lack of trust would have an adverse impact on the realization of the project.

2.2 Stakeholder management

According to Savage et al. „*the project cannot be accomplished without the willingness and ability to contribute by stakeholders with high help potentials, and the avoidance of adverse actions from stakeholders with high harm potentials*" (Eskerod & Vaagaasar, 2014). For this reason, it is easy to conclude that adequate managing of stakeholders and especially their expectations plays a significant role in the successful implementation of the project. Stakeholders will not choose to participate in the project voluntarily; however they need an attractive reason for their engagement.

Methodologies for successful stakeholder management from different authors can be summarized as the following steps based on (Scholl, 2004):

1. Analyzing stakeholders
    1.1. Identifying stakeholders (grouped into classes of salience);
    1.2. Understanding their likely stance towards the project (present and over time);
    1.3. Comprehensively eliciting their needs and wants in ranked fashion;
2. Choosing stakeholder strategy
3. Paving the path for the stakeholder cooperation on the project

Stakeholder analysis is the most important part of the stakeholder management (Missonier & Loufrani-Fedida, 2014). In the event, that there is no precise definition of a stakeholder, it is impossible to determine whether relevant stakeholders are identified, and consequently, whether the analysis has been done properly (Achterkamp & Vos, 2008). For this reason, it is necessary first to identify relevant stakeholders and then categorize them into groups according to their significance for the project. Significance of the stakeholders is measured by their potential influence and their concern for the successful implementation of the project.

Stakeholder engagement is necessary for accurate determination of their significance and later phases of stakeholder management. It includes communication, participation and development of relationships between stakeholders, and because of its impact on the stakeholder analysis and decision making it is crucial from the very beginning of the project implementation (Missonier & Loufrani-Fedida, 2014). Self-interest is probably one of the most important determinants of the stakeholder motivation to participate in a particular project (Purvis et al., 2014).

The second step in stakeholder analysis is the understanding stakeholders' attitude towards the project and identifying his expectations. This step requires a lot of time. During the project and after its completion, the IT project manager has a difficult task of determining, by talking to other stakeholders, what is that they actually want and expect.

The third step in stakeholder analysis involves classification of stakeholder needs and expectations in groups ranked according to their significance. It is important to emphasize that it represents a challenge for the IT project manager to balance all those complex and conflicting perspectives of different stakeholder groups, while the unpredictable participation is a common problem in IT projects (Walton, 2013).

For stakeholder management to be a success, after the stakeholder analysis it is necessary to choose and implement a suitable strategy. According to Savage, there are two types of strategies "integrative" and "distributive". "Integrative" strategies are the ones whose goal is creating a win-win outcome for the focal organization, as well as stakeholders; while "distributive" strategies are the ones where the focal organization is trying to create a win-lose outcome to the detriment of the stakeholders (Eskerod & Vaagaasar, 2014). Taking that into consideration we can say that implementation of "integrative" strategies leads to successful project realization and continued collaboration with the stakeholders; whereas, "distributive" strategies only fulfill short-term goals and have no strategic significance.

Savage asserts that *"fundamental stakeholder management strategy is to transform the stakeholder relationship from a less favorable to a more favorable one"* (Eskerod & Vaagaasar, 2014). Building mutual trust is imperative for successful collaboration with the stakeholders (Siew, 2014). Apart from successful collaboration, in order for the IT project to be successful, stakeholders have to be involved in the decision-making process, and participatory management techniques have to be applied (Eskerod & Vaagaasar, 2014).

The last step in stakeholder management ensures the collaboration between the stakeholders; that is a crucial factor for the implementation of the project. Frequent and purposeful communication is, for this reason, fundamental. Krane et al. state *"that stakeholder management relies on effective communication with all stakeholder groups. And quite often, good communication with crucial stakeholders will become a crucial element in keeping the project uncertainty at an acceptable level"* (Johansen, Eik-Andresen, & Ekambaram, 2014). To ensure successful communication an adequate management is necessary. Communications management includes planning and distribution of the information, managing stakeholder expectations and generating performance reports (Pokharel, 2011). According to this author, frequency of communication is not what makes it successful, but the constant flow of related information.

3 Research Methodology

In order to investigate the level of practical implementation of theoretical knowledge about the collaboration between key stakeholders in IT projects (manager and client) on one side,

and the determination of their satisfaction with the results of IT projects on the other, a survey was conducted in the Republic of Serbia, which involved 40 individuals - 25 IT project managers and 15 IT project clients. Target groups were interviewed with questions that were structured and divided into three groups. The first group of questions included general questions about their prior professional work and participation in IT projects. The emphasis in this group of questions for IT project managers was on researching their participation in the sales phase, before the start of the IT project (Savolainen & Ahonen, 2015). On the other hand, IT project clients were thoroughly questioned about the number of IT projects they had previously commissioned. The second group of questions considered the size and complexity of IT projects in terms of the number, geographic distance, the diversity of interests and levels of intolerance between the key IT project stakeholders (Vidal et al., 2011). Also, this group included questions related to the frequency of communication and the level of cooperation between the IT project manager and the IT project client. The last group of questions focused on examining the perspectives of key stakeholders about the reasons for success and failure of IT projects, as well as general satisfaction with IT projects in which they have participated so far (Lehtinen et al., 2014) (Davis, 2014).

4 Results and discussion

The sample analysis of interview subjects indicates that these are mainly IT project clients that have been in managerial positions for seven or more years (73%), and that commissioned, on average, four IT projects. On the other hand, the sample included IT project managers that have been working in that capacity for four or more years (76%) and during that period managed, on average, more than 15 IT projects. It can be concluded that for the purpose of this study, interview subjects have enough experience to answer questions and give relevant and quality information about this topic.

In terms of the participation frequency of IT project managers in sales phase of the IT project, the results show that 28% of IT project managers have been involved, every time or almost every time, in the sales phase. Consequently, 72% did not participate in the sales phase of the IT project. It is clear that the majority of IT project managers missed the first opportunity to hear the demands directly from the client. In these circumstances there is a risk that members of the sales team would not adequately convey client's demands to the IT project manager and for this reason, start the chain of misunderstandings between the key stakeholders of the IT project.

The perspective of the IT project complexity includes four criteria: average number of project stakeholders, average geographical distance of stakeholders, the average level of interest variation, and the average level of intolerance between stakeholders. Research results show that the sample mainly refers to the projects of medium complexity. On average, they included up to five stakeholders (68%) with moderately pronounced difference of interests (48%). In addition, IT projects were, on average, mainly implemented in the Republic of Serbia (76%). On the other hand, relatively high intolerance between a small number of stakeholders (48%) indicates an unsatisfactory level of cooperation. In addition, IT project managers said that in 50% of cases, where there were five stakeholders, there was intolerance between the smaller number of stakeholders. For this reason, the conclusion is that even in the projects of relatively little complexity, intolerance and misunderstandings between stakeholders are expressed.

The quality and frequency of communication between key IT project stakeholders were observed using two criteria: initiation of mutual communication and improvement suggestions

by the IT project manager. According to the first criterion, IT project managers stated that, on average, they contacted IT project clients at the end of every phase of IT project development, or more frequently (88%), while the IT project clients, on average, contacted them very frequently (56%). On the other hand, IT project clients said that IT project managers informed them about the progress, on average, at the end of every phase of development and more frequently (33%), while they emphasized that they contacted IT project managers very frequently (60%). Discrepancies in the results of the frequency of communication directed to IT project clients, from the perspectives of both IT project managers and clients, may imply transfer of responsibility for problems that occurred on the project. However, it is possible that what we have here is a case of ineffective reporting system. According to the second criterion, IT project managers said that, on average, they frequently informed clients about possible improvements of the IT product (92%). However, according to IT project clients, on average, IT project managers frequently informed them about possible improvements (40%). These results suggest that despite the relatively frequent communication and medium level of suggested improvements, the trust and cooperation between stakeholders are at a very low level, and they represent critical factors in their collaboration.

Results indicate that the key IT project success factor, from IT project manager's perspective (60%) and IT project client's perspective (73%), is the final IT product compliance with client requirements. On the other hand, there are contrasting opinions of key stakeholders about the dominant reason for IT project failure. IT project managers see frequent changes made by IT project clients, as an indication that they do not know what it is they want as a final result (56%). However, IT project clients questioned by this survey stated that, not fulfilling all of their demands was the biggest reason for IT project failure (60%). Disagreement about the key reasons for IT project failure shows that there is a pronounced problem with the communication between key stakeholders, lack of trust and collaboration, client's insufficient understanding of the subject matter and IT project managers' lack of patience for the client. This conclusion confirms the research results of (Pokharel, 2011) that frequent communication between stakeholders is not crucial for the successful collaboration; what is crucial is a constant flow of related information.

The summary of key stakeholder satisfaction with previous IT projects they participated in shows that 72% of IT project managers and 50% of clients were completely satisfied with achieved results. Different levels of satisfaction of key stakeholders can be mainly explained by their entirely different perception of crucial factors for the IT project's potential failure.

5 Conclusions and Recommendations

Based on the stakeholder and IT project management review and on the results of the survey, it is clear that there are several critical issues on the road to successful output deliverance to the IT project client in the Republic of Serbia. Those issues include: IT project manager's involvement in the sales phase, complexity of the IT project in relation to stakeholders, quality and frequency of communication, mutual trust, collaboration, perspectives, perception and education of key stakeholders. For these issues to be resolved there has to be additional education and training for IT project managers, concerning management of stakeholders and their expectations. Also, it is highly recommendable that they participate in the sales phase of the IT project. Equally important is the need for the education of the client about what is there for them to gain by implementation of different IT products and about what they can expect as a result of an IT project. Client education is mainly the responsibility of the IT project manager; they are the ones that are supposed to introduce the client to the terminology and

potential results of the IT project. For this reason, only educated stakeholders can raise the level of communication, trust and collaboration to the preferred level and by doing so ensure the efficiency and effectiveness of the IT project realization. In addition, in order to ensure a successful collaboration, mode and frequency of information distribution has to be determined, so it is suitable for all stakeholders. In conclusion, based on the results of the research and on the theoretical analysis of the subject matter, it is indicated that the IT sector in the Republic of Serbia is insufficiently developed and that there is a great need for its further development through key stakeholder education and scientific research in the field.

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Environmental Attitudes of Business Students in Croatia

Ariana Nefat
Juraj Dobrila University of Pula,
Faculty of Economics and Tourism "Dr. Mijo Mirković“ Pula, Croatia
anefat@unipu.hr

Dragan Benazic
Juraj Dobrila University of Pula,
Faculty of Economics and Tourism "Dr. Mijo Mirković“ Pula, Croatia
dbenazic@unipu.hr

Abstract

Environmental damages are increasingly affecting people's lives and, thus, require urgent changes. Our attitudes to the environment are formed throughout life, while those of students are particularly important because they are the ones who will conduct social changes in the future. The current paper is aimed at studying the environmental attitudes of business students, since they represent the foundation for modelling education and their future behaviour in the business environment. The study was conducted on Croatian business students. Following increased ecological awareness in the world, the results of the current study also show that business students have positive environmental attitudes. No significance difference was found between male and female students. They are willing to acquire as much environmental knowledge as possible, they prioritise field work, and the students who enrolled the course on environmental protection show more positive attitudes. In comparison with modern products, they favour environmental protection, but in case of transportation they are not willing to give up their comfort to protect the environment. Besides, they are not enough prone to waste recycling. It can be finally concluded that environmental issues are very complex today and require efforts shared by all the included subjects, with a focus on the education of young people.

Keywords: Enviromental attitudes, ecology, enviromental awareness

1 Introduction

This age is marked by abundance in material things of which production and consumption, at the same time, means environmental harm. As time passes, people become more and more aware of the necessity to protect their environment, and the quality of their lives, even survival itself, depends on it. The approach to the natural environment and its protection is increasingly becoming important, leading to the global process (Falkner, 2012) which is directed not only towards the protection of nature and natural resources but is also integrated into the idea of sustainable development; thus, it considers economic, natural and social context (Environmentalism today). In this process, attitudes of young people in particular are

important as they represent a significant potential factor of change in attitudes to the natural environment (Rohrschneider, 1988). They get matured with regard to their awareness of environmental issues and, if directed properly, they positively change their attitudes. It is usually a slow process that should not necessarily lead to proenvironmentalist behaviour in a short term (He, Hong, Liu, Tiefenbacker, 2011, Thapa 1999).

Starting from the above-mentioned, the paper is aimed at investigating student attitudes to environmental issues and protection. This population is particularly significant because students represent the future of business world in which the approach to the natural environment will be an important factor of making business decisions.

The paper first considers the characteristics of environmental attitudes. Then, it presents the analysis of student attitudes to the environment, which is used for the hypotheses about their characteristics, influence of gender and education in relation to the environment. The study has been conducted on the sample of Croatian business students.

2 Environmental attitudes

2.1 Characteristics of environmental attitudes

Attitudes are 'learned predispositions to respond in a consistenly favorable or unfavorable manner with respect to a given object' (Fishbein, Ajzen 1975, 6). Since the main characteristic of an attitude is its affective nature, it can be seen as a 'person's general feeling of favorableness or unfavorableness toward some stimulus object.' (Fishbein, Ajzen 1975, 216). Opposite to the classical picture of the structure of attitude viewed as a cognitive, affective and behavioural component, recent theoretical approaches have shown a attitude as evaluative tendency, in interaction with beliefs, affect, and behaviour (Milfont, Duckitt, 2010). Considering environmental issues, attitudes can be divided into 'environmental attitudes' and 'attitudes towads a specific environmental behaviour' (Hines, Hungerford, Tomera, 1986, Mobley, Vagias, DeWard, 2010) which represent different concepts, just as environmental attitudes can be general and specific.

Attitudes are learned predispositions which exist in accordance with a situation (Schiffman, Kanuk, 2000, Blake 2001). They are dependent on various factors (Hasan, Akhter, 2011). According to Kim (2010), they can be recognised as social structural variables (gender, age, income, education) and social value variables (economic value, conservatism, egoistic value, feminism, religiosity). Especially within the global framework, there is a difference in the structure of attitude between developed and undeveloped countries **(**Bostrom, Barke, Turaga, O'Connor, 2006), modelled by different cultures (Sarigollu, 2009, Deng, Walker, Swinnerton, 2006)**.** The needed evaluation of the influence which individual and contextual factors have on the attitude has been also pointed out by Boewe-de Pauw, Van Petegem (2010), who investigated young people from 56 countries in the world. Yet, there is a general tendency to an increase in environmental concern (Cao, Chen, Liu, 2009).

2.2 Student environmental awareness and attitudes

Universities are the places where young people get matured to be able to govern the society and conduct social changes tomorrow. Zsoka, Szerenyi, Szechy and Kocsis (2012) have found that the awareness of university students with regard to environmental issues is at a higher level than that of high school students. Their interest in environmental issues is not recent. Positive environmental attitudes in the USA, for instance, have been found by Tharpa

(1999), and Kennedy, Hyde and Karney (2002); the latter ones have shown that student attitudes are more influenced by local environmental issues. A study conducted in Taiwan has led to the conclusion that they are aware of important environmental problems and give priority to environmental protection instead to economic development (Wong, 2001). In accordance with the general fact, there is a difference in attitudes between particular countries as shown by Kilbourne, Beckmann, Lewis and van Dam (2001), who investigated students in England, Denmark and the USA; Lee, Barnowe and McNabb (2005) have also established differences between the USA and Taiwan in the perceptions considering numerous threats and dangers related to the natural environment.

Students themselves are not a homogenous group when their environmental attitudes and behaviour are taken into account. Although studying at different faculties may not affect student attitudes and behaviour (Muderrysoglu & Altanlar (2011), a comparison of environmental awareness and concern between ecology and business students by Wysor (1983) has shown that business students are less environmentally aware and concerned. In addition, Benton (1994) has confirmed that business students may not be less knowledgeable, but they are less concerned and willing to responsibly behave towards the environment in comparison with non-business students. Starting from the above-mentioned studies with different results, but taking into account a general increase in the awareness of environmental issues and protection, the following hypothesis can be suggested:

H1: Business students show positive environmental attitudes

Based on studies by Fernandez-Manzanal, Roddrigues-Berreiro and Carrasquer (2007), as well as those by Tikka, Kuitunen and Tynys (2000), female university students show more positive environmental attitudes. Specifically, a study by Haytko and Matulich (2008) has shown that female students have significantly more positive attitudes to green advertising, and their environmental behaviour is more responsible. Such result has not been supported by all studies conducted on a student sample. Chen and Chai (2010) have established no difference in the attitude to the environment and green products between female and male students, just as Muderrysoglu and Altanlar (2011) have not confirmed any significant difference in their attitude; yet, male students are more responsible to the environment through their consumerism behaviour, while female students are more responsible when it comes to recycling. This leads to the following hypothesis:

H2: Female students show more positive environmental attitudes than male students

Knowledge about environmental protection and attitude to it can be improved during pre-university education (Campbell, Bradley, Waliszek & Zajicek, 1999). Further on, environmental education in the university period affects an increase in the environmental awareness of students and their life style (Szerenyi, Zsoka, Szecky, 2010), and results in better student attitudes (Rodriques-Barreiro et al., 2012). Therefore, the knowledge and attitudes of students who had study courses related to ecology are at a higher level than those of students who did not have them (Pe'er, Goldman, Yavetz, 2007). The aspect of environmental protection is an important component of sustainability. A study conducted in the USA by Kagawa (2007) has shown that students with very positive attitudes to sustainability and sustainable development strongly relates this term to the ecological aspect. So, ecology-related eduction should also include a wider concept of sustainable development, which more thoroughly covers the issues of modern society. Since education is not the only source of information about the environment, the influence of education should be considered in the context of other factors that sometimes can be stronger (Suplico, 2009, Hassan, Ismail, 2011). The following hypothesis about ecological education is:

H3: Ecology-related education affects the improvement of environmental attitudes

3 Study of student environmental attitudes

3.1 Methodology

There are many instruments for measuring environmental attitudes, but only three of them are widely used: Ecology Scale, Environmental Concern Scale and New Environmental Paradigm (Milfont, Duckitt, 2010). In this paper, student environmental attitudes have been measured by the scale that was developed by Fernandez-Manzanal, Rodriguez-Barreiro and Carrasquer (2007); it was adapted for students and included 20 items.

The study included the first, second and third-year undergraduate students and first-year graduate business students (who had enrolled study courses with regard to ecological and environmental issues) at the Department of Economics and Tourism Dr Mijo Mirković – Juraj Dobrila University of Pula. A total of 247 questionnaires were collected from 27.9% male participants and 72.1% female participants.

3.2 Results and discussion

Table 1 shows the results of descriptive analysis. Items 1, 4, 6, 10, 11, 13, 14, 16, 18 and 20 are negative, so they were reversely coded at calculating the total value of attitude. Cronbach alpha for the entire scale was calculated to be 0.781, indicating the reliability of the scale used for measuring environmental attitudes.

	Items	Arit. sred.	Std.Dev.
ENV1	Environmental education for people cannot help to resolve environmental problems, only technology can do this.	2.13	1.033
ENV2	Universities should schedule more field activities because they help to understand the matter better.	3.81	.966
ENV3	I am willing to consume less and go without some comforts if it helps to protect the environment.	3.28	.994
ENV4	I believe that environmental problems are exaggerated, nature balances out over time.	2.02	1.034
ENV5	When I buy a product, I assess the type of packaging and choose one that is recyclable.	2.13	1.065
ENV6	The progress of a district should not be held up with the excuse of protecting some birds.	2.63	1.216
ENV7	I like to participate in field activities because it is a good way of understanding the environment in which I live.	3.51	1.100
ENV8	I believe that information is increasingly necessary to be aware of the effects our actions have on the environment.	3.82	.911
ENV9	I try to choose subjects that deal with matters related to the environment because I feel that I do not know enough.	2.49	,975
ENV10	Nowadays the laws and government regulate and control so much that there is very little contamination.	1.55	.799
ENV11	If I have to choose between the construction of a motorway and the protection of a plant species, I choose the motorway.	2.49	1.209
ENV12	Field activities help to be more in touch with nature.	4.13	1.037
ENV13	In order to have a more technologically developed society, I am willing to tolerate noise caused by vehicles.	2.50	1.008
ENV14	The benefits of modern consumer products are more important than the contamination caused by their production and use.	2.54	.978
ENV15	Field activities help to increase awareness of environmental matters.	3.96	.976
ENV16	Even if public transport were more efficient than it currently is, I would still prefer to use my own car.	3.29	1.234
ENV17	In my opinion, the more people know about the natural environment the better their defence attitude.	3.60	.999
ENV18	Environmental education activities are only useful for children.	1.83	.974
ENV19	We should try to conserve the Earth's plants and animals, even though it is expensive.	4.29	.881
ENV20	Field activities are a waste of time, the most important thing is class work.	1.62	.921

Source: Authors' calculations

Table 1: Descriptive statistics – environmental attitudes

The results show that students most disagree with negative items ENV10 (**Error! Objects cannot be created from editing field codes.**=1.55), ENV20 (**Error! Objects cannot be created from editing field codes.**=1.55) and ENV18 (**Error! Objects cannot be created from editing field codes.**=1.83), but they most agree with ENV19 (**Error! Objects cannot be created from editing field codes.**=4.29), ENV12 (**Error! Objects cannot be created from editing field codes.**=4.13) and ENV15 (**Error! Objects cannot be created from editing field codes.**=3.96). According to the results, students are sensitive to environmental issues on average. The total value of attitude is 3.66 (σ =0.433), and it is significantly different (t=23.97; $p<0.05$) when compared with the means (3) of the Likert-type scale that has been used. The results show that student attitudes to the environment are positive, which confirms H1. With regard to gender, there is no statistically significant difference (t=-0.23; $p>0.05$) between male (**Error! Objects cannot be created from editing field codes.**=3.65, σ=0.53) and female students (**Error! Objects cannot be created from editing field codes.**=3.66, σ =0.391). This result supports the study conducted by Chen, Chai (2010), but it does not support other studies, which may lead us to the conclusion that it is not possible to generalise attitudes to environmental protection according to gender. Business tudents generally think that discussions and warnings about environmental protection are exaggerated, which may indicate that their ecological awareness is not at the required level. Generally speaking, people are not aware of the damage in the environment made through economic activities; it especially refers to global climate changes that are becoming locally more and more obvious. Yet, they are willing to learn about changes in the environment and think that adequate information is surely needed. Since they think that environmental education should not be restricted on the early age, but also included later, they support this idea in higher education. It is, therefore, clear that they are open to formal education (in this case) about environmental protection, which should be noticed by universities in order to suggest more comprehensive study programmes dealing with such issues. There are different educational possibilities, and students prefer field activities. The above- stated points out that universities should not be restricted only on theoretical knowledge, but the acquisition of knowledge should be conducted through observing concrete problems and considering their solutions. Students have various projects openly available to them to give their contribution. Taking into account student education related to environmental contents, the obtained results are indicative. The students (n=14) who attended environmental courses have more positive attitudes (**Error! Objects cannot be created from editing field codes.**=3.93, σ=0.44) in comparison with their colleagues who did not enroll such courses (**Error! Objects cannot be created from editing field codes.**=3.64, σ=0.43). The total student population gives priority to education in relation to exclusively technological improvements of envronmental protection, which may indicate that they are not aware of technological changes which lead to less environmental pollution, and that they think that education is, above all, important as it makes society ecologically conscious and motivates the community of humans to find new technological solutions. It is positive that they do not prefer the advantages of modern products which contribute both to comfortable life and polluted environment. The above-stated confirms that they do not uncritically accept various ecologically harmful products, but they still consciously consider their influence on the environment. However, when it comes to transport, there is something contradictory with regard to the stated above. Although all the participants are generally willing to give up certain forms of comfortable life in order to protect the environment, they are not willing to give up driving their own cars instead of using the public transport. Based on the previously mentioned, it can be said that participants want technological solutions within contemporary life-style that will not considerably damage the standard of living already accomplished. This supports the results of numerous studies that

show positive attitudes to environmental protection, but when concrete behaviour is considered – which is said to decrease the features of comfortable life – people are not willing to change their behaviour. Students are sensitive to the protection flora and fauna although this can be demanding. This problem is current in particular, as global climate changes cause the dramatic extension of flora and fauna, to which an individual can slightly contribute. Some more considerable contribution to environmental protection is possible at the governmental and legislation level; and participants think that there has been no sufficient engagement in this sense. On the other hand, they do not incline to ecologically responsible behaviour considering the purchase of recyclable products, which again points out the importance of education, but also activities of companies and other subjects, in promoting more responsible everyday consumption behaviour that protects the environment. People's willingness to behave in a more responsible way in order to protect the environment through the care of garbage is not enough, but adequate storage and system of reverse logistics are also needed. All that has been mentioned above can lead to the conclusion that environmental protection-related education is very important in every stage of life-cycle, also at university age, providing young people with more complex insights and enabling them to later become ecologically conscious individuals that will lead the society to more responsible environmental behaviour. But it is also important to know that these changes are slow and complex because they require shared engagement of several subjects in the society, especially companies that will accept sustainable business and people who will be willing to conduct the activities of environmental protection in practice.

4 Limitations and further research

Although the used scale is to be considered reliable in the given context, the paper limitations with regard to its use covering specific questions can be resolved by conducting research on the same population by applying other scales of more universal character. Following other studies (Benton 1994, Wysor 1983) which show that business students are less concerned about environmental protection issues, it would be useful to conduct research on a wider population of students, that could support the given studies or not. In addition, the national sample could be used to determine possible differences between particular regions or rural and urban areas. It is certain that attitudes are not the only issue of significance, but also concrete behaviour regarding environmental protection, so it would be important to study the impact of attitude on environmental protection-related behaviour.

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On-Line Reputation of Selected Providers of Health Care Functioning on Slovak Market

František Pollák
University of Prešov, Faculty of Management, Slovakia
frank.pollak@acuityeng.com

Peter Dorčák
Goethe UNI Bratislava, Slovakia
peter@dorcak.com

Katarína Belovodská
J. A. Reiman Faculty Hospital in Prešov, Slovakia
katarina.belovodska@gmail.com

Abstract

The aim of this paper in the first place is to analyse the theoretical possibilities of detection an On-Line reputation of selected providers of health care functioning on Slovak market. Research is based on new and very current phenomenon of the significance of on-line reputation of selected subjects in a specific type of market. For purposes of this paper, subjects are represented by on-line presence of Slovak providers of health care on virtual market. The target group is narrowed to top 25 Slovak providers of health care according current rating made by Slovakian major health Insurance Company, as the best representation of subjects from the field of health care which officially presented themselves to customers- internet users on the specific type of market. Virtual reputation of those subjects detected by sentiment analysis is compared to their reputation in brick world. In conclusion paper presents options and recommendations to optimizing virtual reputation as well as highlights the differences of perception of reputation in the traditional and in the virtual market.

Keywords: Reputation, Health care, Competition

1 Introduction

Reputation is a concept commonly used in marketing management and it generally means an overall presence on the market. From the point of view of Internet we can compare it to leaving footprints. All activities are interconnected and complement one another (Janouch, 2011, s. 17). Each institution has a reputation or online reputation, whether they want it, or not; the reputation does exist (Marsden 2013). If an entrepreneurs running their own businesses (or managing an institutions), they should not leave their reputation to chance. It is their ultimate responsibility. Company's reputation is considered to be very valuable asset. As George Washington once said: "With a reputation you can do anything without one, nothing" (Haywood 2002, p. 9). However, if we consider corporate reputation, its definition is a bit

complicated (Griffin 2008). Balmer a Greyser (2003) characterize corporate reputation as such which is created over time based on what the organization did and how it behaved. According to Bromley (2002), company's or corporate reputation only reflects relative standing of the company, both internally with its employees and externally with other stakeholders, in both its competitive and institutional environments. Highhouse defines corporate reputation as a global, stable over time, evaluative judgement about a company that is shared by multiple constituencies (In: Helm et al. 2011). It is a pure reaction of customers, investors, employees and other stakeholders. It is a collective judgement of individual impressions (Gottschalk 2011).

2 The issue of reputation in the context of trust

Trust fulfils every organisation in a million of different ways. No institution can function without it. Trust is a strong belief that we can rely on someone (Shore, 2005). Shaw offers alternative definition (In: Armstrong 2007); he defines the concept of trust as a belief that those on whom we depend will meet our expectations of them. These expectations depend on our critical judgement of other person's responsibility to meet our needs. Tavakolifard (2012) claims that generally accepted definition of trust is still missing despite comprehensive studies of philosophers, sociologists and psychologists. It is easier to identify individual features of trust than to determine exactly what it means. We agree with the definition by Gambetta (2000) who argues that trust (or symmetrically, distrust) is a particular level of the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action, both before he can monitor such action (or independently of his capacity ever to be able to monitor it) and in a context in which it affects his own action. An agent is generally an individual or a thing (entity) which affects the environment or other agents and has characteristic and its own targets which it strives to achieve. The contextuality of trust means that the trust of entity "A" towards entity "B" is always dependent on certain context "C". We'd like to point out the work of Jøsang et al. (2005) who deals with "the issue of trust" (in terms of creating trust, establishing credibility and making decisions on the basis of credibility). Jøsang et al. states that trust is an oriented relationship between two parties called the subject and the object. The term oriented is used in the sense of clear distinction of resources (subject) and goals (object) of the relationship. The authors further define two types of trust: Context-independent (reliability trust) - where trust is the subjective probability by which an individual "A" expects that another individual "B" performs a given action on which its welfare depends; and Context-dependent (decision-trust) - Trust is the extent to which one party is willing to depend on something or somebody in a given situation with a feeling of relative security, even though negative consequences are possible. (Jøsang et al. 2005)

2.1 Classification of models based on trust and reputation

Jordi Sabater and Carles Sierra (2003) in their work Review on Computational Trust and Reputation Models have specified classifications which focus on major models and try to find common features based on which individual classification methods and their categories are designed. Basic classification criterion is the so called model type. Model type means whether the model works with trust or a reputation.

- models of trust – work only with trust,
- models of reputation – work only with reputation,
- hybrid models – work both with trust and reputation.

According to these authors, models can be classified on the basis of determining the origin of information (knowledge) which is used for the evaluation of reputation, as well as confidence. These include (Sabater, Sierra, 2003): direct experience, hearsay information, sociological knowledge and prejudice.

3 From the image to the reputation

Companies and organizations in common have invested large amounts of financial resources and hired agencies and marketing professionals to prepare communication campaigns to support such brand image that would create an incentive for the customers to make purchases (Leboff 2011). This argument is supported by Smaiziene and Jucevicius (2009) who claim that companies prefer to focus primarily on the image and leave the reputation behind. Grant Leboff (2011) mentions that the image is not a guarantee of positive comments and recommendations. These will only be achieved due to good reputation. In other words, the foundation of modern marketing is not the image which the organization strives to create, but the reputation which it has actually established. As regards the image and reputation, Bennet and Kottasz point out time dimension (time of creation) as the main characteristics which distinguish these two constructs. In other words, organization's image can be created in a short time. Reputation is generated in a longer time frame, and therefore cannot be changed or redirected as quickly as the image (In: Smaiziene, Jucevicius 2009). Such an approach is also supported by Jackson (2004) who argue that the time of establishment or creation is one of the main differences between the image (short time of creation) and reputation (long time of creation). Fill (2009) perceives reputation as wider set of images. He is also of the opinion that changing reputation is more time consuming and difficult while image can be influenced much faster. Therefore, it may be said that reputation and image are not synonymous, as some authors point out, yet they are closely related and interdependent elements.

3.1 Creation of reputation

According to Svoboda (2009), reputation of any organisation is composed of three forms, i.e. primary, secondary and cyclic. Fombrun and Foss (2001) defined reputation as collective assessment of the organization's ability to provide valuable product, service or other value to a group of customers. They have developed a scale that measures corporate reputation, which they call corporate reputation quotient (RQ). RQ is a complex method of measuring corporate reputation (In: Walsh, Beatty 2007). The building of corporate reputation has been primarily attributed to the area of marketing and communication. Burke et al. (2011) states that nowadays the corporate reputation has been integrated into human resource management and corporate strategy. Reputation is communicated to the public by the organisation's managers. It is generally accepted that reputation begins from the inside out. Fombrun and Foss (2011) noted that it is good if the organisation takes care of its reputation, and they emphasized the following factors:

1. The Principle of Distinctiveness - Strong reputations result when organizations own a distinctive position in the minds of customers.
2. The Principle of Focus - Strong reputations result when organizations focus their actions and communications around a single core theme.
3. The Principle of Consistency - Strong reputations result when organizations are consistent in their actions and communications with internal, as well as external environment.

4. The Principle of Identity - Strong reputations result when organizations act in ways that are consistent with espoused principles of identity. The main task is that the organizations are perceived as real by its customers and the public.
5. The Principle of Transparency - Strong reputations result when organizations are transparent in the way they conduct their affairs. In particular, organizations should be perceived as open and honest in their business activities. Transparency requires communication - a lot of it.

4 Reputation in online environment

Walsh and Beatty (2007) argues that reputation in life and business is everything. It means that reputation is very fragile and one mistake may sometimes cause irreversible damage. This is especially true in the digital world, where radical transparency and demanding customers have the greatest power. According to Janouch (2011), if the Internet offers consumers a new way to share information about companies and brands, then it also allows the companies to control information about them. Consumers are able to obtain information on potential suppliers and products, but they can also create new content on the Internet which may affect the perception of other consumers and stakeholders of the respective organization. Negative comments on the Internet can quickly and seriously damage the image and reputation of the brand (In: Siano et al. 2011). eWOM (electronic word of mouth) is an important part of online reputation. According to Henning-Thurau (2004), this form of communication may be defined as any positive or negative statement made by potential, actual or former customers about a product or organization via the Internet. Jun Loayza (2013) presents basic principles of online reputation management which he divides into various segments such as Quick Fix, Long-Lasting, Content Driven and Relationship Driven.

5 Analysis of Reputation of Health Care Providers on Slovak Virtual Market

Virtual reputation management or, in other words Online reputation management (ORM in short) has ceased to be a novelty or an unknown concept in Slovakia. ORM has been applied in many industries such as banking and insurance. The results of these surveys provide a reliable and current view of virtual presentation of organizations as well as the image of their virtual identities. The level of positive online reputation is not only a source of information for organizations, but also an important factor influencing the decision-making processes of consumers. Using the chosen methodology the online reputation of top twenty-five Slovak health care providers (by survey of VšZP- Slovakian major health Insurance Company, 2013) was investigated. Subjects was selected as the best representatives of entities from health care field officially presenting themselves directly to target customers in a specific virtual market. Methodology called "sentiment analysis" (Roháľ, Sasko, 2011) was used to assess virtual reputation. According selected methodology analysed subjects were assigned numerical values representing scores of their virtual reputation strength on the virtual market which were then compared with their scores (patients satisfaction index) achieved in in the real world, by the survey of VšZP- Slovakian major health Insurance Company. The sequence of the reputation measurement process begins by defining representatives of the segment. We have selected representatives of health care providers in Slovakia in this case. Subsequently, virtual identity of these entities using the Google search engine was studied. For the purposes of the sentiment analysis the first 10 search results was taken into account. To ensure objectivity of the results that may be biased due to the tendency of search engines to personalize the search

through the history of Internet activity, the proxy anonymizer was used in order to increase anonymity. Only organic results were included in the survey, paid contextual advertisements of the Adwords system were excluded. In determining the sentiment the numbers of positive reviews on social networks were not taken into account. Only the fact that an institution owns a profile on any of the virtual social networks was taken into account. The nature of institutions descriptions on the Wikipedia portal was also not taken into account. Only the fact that Wikipedia mentions an institution was taken into account. In both cases, these results were assigned neutral sentiment. If the search engine found, besides an official institution's web site, web pages of institution's faculties or entities associated with such institution on other places in a search, these results were assigned neutral sentiments. If the institution's web site occurred in several places within the search, only the first occurrence was taken into account, where the following occurrences of institution's web site were assigned neutral character. Well known and well established names of entities were used as search phrases, as it was defined in the survey of VšZP- Slovakian major health Insurance Company in full regardless of their home sites. One of the main factors in the evaluation process was sentiment of the results. This can be loosely defined as the nature of results found by entering keywords. Positive, neutral, but also negative feedback can be found in the results. These sentiments, as well as positions on which they were displayed, provided a picture of research subjects, and thus ultimately determine its online reputation. Sentiment of individual results in the Top 10 is clearly shown in the table with a short commentary. At the same time, scores are allocated to each position on the basis of sentiment in the following table:

Sentiment / Position of the result	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Positive sentiment +	20	19	18	17	16	15	14	13	12	11
Custom web site of the organization x	10	9	8	7	6	5	4	3	2	1
Neutral sentiment ±	2	2	2	2	2	2	2	2	2	2
Negative sentiment -	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11

Table 1: [Sentiment individual results / position of results] Source: Roháľ- Sasko (2011)

The table shows chronological sequence of awarding points to analysed entities. Positive feedback or sentiment increases score. The higher the position of this sentiment in search results, the more points it has. Similarly, but with the opposite effect, this applies to identifying negative sentiment. Points are deducted as follows: the higher the position of the sentiment in search results, the bigger the point deduction resulting in rapidly deteriorating reputation. Within the overall evaluation individual sentiments are then totalled, and the sum indicates the strength of sentiment of all ten search engine results for a given entity. The resulting sum of sentiments represents the overall level (strength) of online reputation. For the purpose of comparison entities were then arranged in ascending order based on the overall level of their online reputation in the virtual environment of the Slovak Internet. For better clarity the methodology is supplemented by the parameter of percentage evaluation of the score relative to the maximum possible number of points obtained within the analysis of sentiment (maximum possible number of points = 155, 1p = 0.645%).

The table of overall assessment of sentiments of the top twenty-five Slovak health care providers (and thus the overall level of their online reputation) is as follows:

No.	Healthcare provider / Result sentiment	1	2	3	4	5	6	7	8	9	10	Score (on-line) in points / %	*Score (VšZP) in %
1	FN Trenčín	x	±	+	±	±	+	±	±	±	+	**64 / 41.29**	67.53
2	Nemocnica Košice - Šaca a.s. 1. súkromná nemocnica	x	±	±	±	±	±	+	±	+	n	**50 / 32.26**	78.02
3	KARDIOCENTRUM NITRA s.r.o.	x	+	±	±	±	±	±	±	±	±	**45 / 29.03**	80.94
4	OFTAL, očná klinika, Zvolen	x	+	±	±	±	±	±	±	±	±	**45 / 29.03**	80.83
5	Národný ústav srdcových a cievnych chorôb, a.s.	x	±	±	±	+	±	±	±	±	±	**42 / 27.10**	81.14
6	Univerzitná nemocnica Martin	x	±	±	±	±	+	±	±	±	±	**41 / 26.45**	67.40
7	Východoslovenský onkologický ústav, a.s.	x	±	±	±	±	±	+	±	±	±	**40 / 25.81**	75.3
8	Nemocnica sv. Michala, a.s.	x	±	±	±	±	±	+	±	±	±	**40 / 25.81**	72.43
9	Onkologický ústav sv. Alžbety s.r.o.	x	±	±	±	±	±	±	±	+	±	**38 / 24.52**	82.01
10	Národný ústav tuberkulózy, pľúcnych chorôb a hrudníkovej chirurgie, Vyšné Hágy	x	±	±	±	±	±	+	+	-	±	**37 / 23.87**	80.3
11	Východosl.ústav srdcových a cievnych chorôb, a.s.	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	81.96
12	Národný onkologický ústav	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	81.43
13	Univerzitná nemocnica s poliklinikou Milosrdní bratia, spol. s.r.o.	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	80.98
14	Národný endokrinologický a diabetologický ústav n.o.	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	80.82
15	Stredoslovenský ústav srdcových a cievnych chorôb	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	79.03
16	Ústredná vojenská nemocnica SNP Ružomberok - fakultná nemocnica	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	76.15
17	NÚRCH Piešťany	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	74.22
18	Železničné zdravotníctvo s. r. o. Košice	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	70.61
19	FNsP F.D. Roosevelta Banská Bystrica	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	69.92
20	Ľubovnianska nemocnica, n. o.	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	69.65
21	NEMOCNICA Handlová - 2.	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	68

	súkromná nemocnica, s.r.o.												
22	NsP Nové Mesto nad Váhom, n.o	x	±	±	±	±	±	±	±	±	±	**28 / 18.06**	66.83
23	Mammacentrum sv. Agáty, Banská Bystrica	x	±	±	±	±	-	±	±	±	±	**25 / 16.13**	81.09
24	Regionálna nemocnica Sobrance, n.o.	x	±	±	-	±	+	±	±	±	±	**22 / 14.19**	74.05
25	FN Nitra	x	±	±	±	-	±	+	±	±	±	**22 / 14.19**	68.04

Table 2: [Overall rating of sentiments of analysed entities] Source: our data, according to Roháľ- Sasko (2011)

Notes: * Patients index satisfaction according to VšZP (Slovakian major health Insurance Company), 2013

6 Results of the analysis

Based on the analysis it is clear that within the virtual identity of researched entities (top twenty-five healthcare providers in Slovakia according to VšZP- Slovakian major health Insurance Company) web sites owned directly by providers are at the top places of search. The dominant group of sentiments consists of search results of neutral sentiment. Negative sentiment was reported with only few entities, on the fourth, fifth, sixth and ninth positions in search respectively (one occurrence had unfavorable evaluation in the Azet.sk catalogue; others had negative publicity on a blogs, forums and electronic media respectively). Entities that occupy top positions have, in terms of virtual reputation among Internet users, undeniable benefit in the form of a more positive perception of their complex virtual identity. If users search for information about a particular institution providing health care and encounter negative references, it can ultimately affect their overall perception of the given institution. Especially if these users do not have any personal experience with a given institution and judge only on the basis of information from the virtual environment. Facilities providing health care should therefore make sure to make necessary information available to Internet users in the most clear way possible. It is in their own interest to ensure the elimination of negative publicity (and vice versa reinforce positive publicity) for at least the first ten positions in search engines. This can be achieved by active Internet communication policy in the form of spreading positive information on major Internet players, such as electronic versions of major Slovak dailies or through virtual social networks, Internet forums and discussions. The best way to eliminate negative or neutral publicity in the first ten search engine results is a literal displacement of such publicity by actively working on a coherent marketing communications policy on the Internet. The most interesting finding was a demonstration of relatively low percentage of achieved reputation in the online environment considering the high percentage of reputation (considering high patients satisfaction index) achieved within the real world. This points to the fact that over a period of time the very best health care providers managed to optimize the factors and processes that have contributed significantly to increase their reputation in the real world (and thus increasing patient satisfaction index), but in the virtual environment are still a long way to go. Notional value of 100% or 155 points achieved in the sentiment analysis is, in this case is "only" sort of imaginary, in the real world almost unattainable state. In any case, at the currently achieved average values of 21.86% of the total possible strength of virtual reputation, any proactive action of an entity aimed at optimizing reputation in the virtual environment is more desirable.

With such small differences within the analyzed entities it also possible to achieve a significant progress towards top positions against competition exerting fewer resources (financial, time, human). As already mentioned, the methodology presented is one of many methodologies used for the assessment and measurement of online reputation. Its complexity, clarity and relatively low time demandingness predisposes it to be used for the purpose of assessment of online reputation of various entities such as public institutions, companies and even individuals using the Internet for purpose of personal branding.

7 Conclusion

In today's internet era only highly specialized power elites using new technologies come to the fore. It is a general effort in applying marketing tools to build a quality brand and publicizing the brand to wider audience. It does not matter whether it is a product, service, or organization. This paper has shown the importance of reputation in the online world that can harm a brand, or the image within milliseconds while searching for information on the Internet. For the purpose of this paper ranking levels of online reputation of Slovak top 25 health care providers (according to VšZP- Slovakian major health Insurance Company) was processed and their subsequent comparison with the ranking identified in the real world shows substantial differences between these two views. The result of the perception of reputation, also on the basis of this paper, may be a good and targeted communication, which is part of the marketing mix. Positive reputation, especially in the online environment of immediate decisions, is often a critical factor for customers when purchasing products, visiting an institution, or ordering services. In addition to a long built positive image it is therefore important to regularly verify the level of reputation and eliminate negative news, especially in such an important market area as the provision of health care.

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Managing Exploration and Exploitation in Alliance Portfolio: When One Plus One is More than Two

Mladenka Popadić
University of Rijeka, Faculty of Tourism and Hospitality Management Opatija, Croatia
mpopadic@fthm.hr

Matej Černe
University of Ljubljana, Faculty of Economics & CO BIK, Slovenia
matej.cerne@ef.uni-lj.si

Ines Milohnić
University of Rijeka, Faculty of Tourism and Hospitality Management Opatija, Croatia
ines.milohnic@fthm.hr

Abstract

This study advances the on-going debate on importance of balancing exploration and exploitation activities across their organizational boundaries. Basing our work on the assumption that balance is needed; we empirically test whether firms need to forward their attention to exploration and/or exploitation activities in alliance context. Using a large panel of innovative firms in the 13 countries, this study shows that exploration oriented alliances in a firm's alliance portfolio have a positive effect on firm's innovation performance, while exploitation oriented alliances exhibit negative ones. Our analysis confirm foundation in earlier work, that balancing exploration and exploitation activities are beneficial, and that exploring via externally oriented levels such as alliances enhances firms innovation performance, but not vice versa.

Keywords: exploration, exploitation, innovation performance, alliances

1 Introduction

A major challenge for firms is the need to continually develop new knowledge (e.g. exploration) and refine existing one (e.g. exploitation) (Levinthal & March, 1993) and thereby remain competitive on a long-run (March, 1991). As exploration and exploitation entail different skills, firms often struggle with a dilemma whether to support one activity at the expense of the other (Stettner & Lavie, 2013), or whether paying more attention toward exploration or exploitation is conductive to higher firms log-run performance (Gatti, Volpe, & Vagnani, 2015). An abundant body of extant research was inspired by this dilemma, including strategy and organizational learning literature (Lavie & Rosenkopf, 2006; Levinthal & March, 1993; March, 1991), organizational design (Tushman & O'Reilly, 1996), and innovation (Rothaermel & Deeds, 2004). However, a critical determinant of long-term success and conversely positive performance effects is the firm's ability to balance both activities, i.e. ambidexterity (He & Wong, 2004; Lavie, Stettner, & Tushman, 2010; March, 1991).

As exploration and exploitation require different sets of capabilities, engaging in both activities is generally challenging for firms (Lavie et al., 2010). Thus, scholars have acknowledged the importance of testing ambidexterity premise in the specific context - alliances (Lavie & Rosenkopf, 2006). Moreover, within these challenges alliances are seen as a valuable context for fostering both activities. On the one hand, alliances are providing firms with valuable resources, especially in the form of new knowledge, e.g. exploration (Powell, Koput, & Smith-Doerr, 1996). On the other hand, alliances also must invest in exploitation activities in order to limit cost, and consequently reap the benefits of already deployed combinations (Gatti et al., 2015). Despite these advancements, inconsistent research findings leave the nature of the relationship between balancing exploration-exploitation via alliances and performance contested (Das & Teng, 2003; Stettner & Lavie, 2013). Given to vagueness in definitions of exploration-exploitation constructs, considering more specific acts of exploration and exploitation activities (e.g. new generations of products, refinement of existing products) that stem from firm collective efforts (Gatti et al., 2015) and testing their effect on more fine-grained performance measures such as innovation performance would add valuable insight in fragmented body of extant research (Junni, Sarala, Taras, & Tarba, 2013).

The balancing view is embedded in the concept of organizational ambidexterity (He & Wong, 2004) and refers to the firms need to achieve a "balance" between the two activities to achieve superior performance (Tushman & O'Reilly, 1996). We challenge the ambidexterity argument (Benner & Tushman, 2003; Gibson & Birkinshaw, 2004; Raisch, Birkinshaw, Probst, & Tushman, 2009) and apply the exploration versus exploitation construct to characterize how firms strategically prioritize their explorative and exploitative activities in alliances, and examine their separate effects on the innovation performance of these firms (Nielsen & Gudergan, 2012; Raisch & Birkinshaw, 2008). In this study, we contribute to the literature by providing a large-scale empirical test of the basic theoretical relationships between exploration, exploitation and innovation performance. These relationships are analyzed using the CIS 2006 survey that covers the years 2004-2006. Specifically, we contribute to the organizational learning and alliance literatures by studying the intensity of exploration and exploitation, respectively, in the context of alliances (across organizational boundaries) which leads to the highest levels of innovation performance. We argue that boundary spanning via alliances; external "mode of operations" e.g. level of analysis, can be beneficial in certain time for one of the activities, but not for both. Russo and Vurro (2010) examined the performance effects of balance within one mode (via alliances), and find that internal (within organization) exploration will generate a positive performance impact on innovation performance only if it's accompanied with external exploration. Stettner and Lavie (2013) ENREF 35 extended this notion and contributed to the aforementioned lately-predominant research on the balance of firms' exploration and exploitation, but across different modes (via internal organization, acquisitions and alliances). Thus we advance research on organizational ambidexterity (Lavie et al., 2010). This paper proceeds as follows. In what follows, we develop theory with respect to the relationship between exploration and exploitation and innovation performance followed by the data and methods section, which explains the empirical approach. The research results are reported followed by a discussion of the implications of our study for theory and practice and suggested directions for future research.

2 Theory and Hypotheses

2.1 The Exploration and Exploitation

To deal with the uncertainty and ambiguity of external environment, firms' preference for forming the alliance is often based through the choices of alignment and adaptability or as March (1991) ENREF 22 hypothesizes "exploration" and "exploitation". March (1991) linked knowledge management and innovation to explain paradoxical nature of exploration and exploitation activities. From this viewpoint, firm's choice of the type of alliance to enter can be distinguished by its motivation to either explore new opportunities or exploit existing ones. It is still present confusion regarding the precise definition of exploration and exploitation, and therefore the ambiguity and vagueness in using terms such as exploration and exploitation is still present in the literature (O'Reilly & Tushman, 2013).

On the one hand, in exploitative alliances, the main objectives relate to the leveraging and further developing existing technologies (Faems, Van Looy, & Debackere, 2005; Koza & Lewin, 1998), or present complementarities between products and technologies (Teece, 1992). The goal of the exploitation alliances is joining existing competencies with complementary assets that exist beyond a firm's boundary (Rothaermel & Deeds, 2004). Explorative alliances, on the other hand, are formed to seek and generate new knowledge and technologies (Rothaermel & Deeds, 2004), as well as creating new resources and competencies to adapt to the environment (Koza & Lewin, 1998). The need for firms to engage in exploratory and exploitative activities has been frequently emphasized (Gupta, Smith, & Shalley, 2006; O'Reilly & Tushman, 2008), which raises a question of how to successfully balance them, especially in context of alliances (Lavie & Rosenkopf, 2006). To date, there is still a vivid scholarly debate on the nature of exploration and exploitation in the present literature (Gupta et al., 2006; Lavie et al., 2010; Stettner & Lavie, 2013). Scholars predominantly theorized and empirically supported two opposing views. Proponents of first one, continuum-balanced view, claim that exploration and exploitation constitute two ends of continuum, and that they should be balanced (Lavie et al., 2010; Raisch et al., 2009), while the others, proponents of orthogonal view, claim that they should be viewed as two separate and independent dimension of firm activities (Gibson & Birkinshaw, 2004; O'Reilly & Tushman, 2013). Although, we acknowledge the premise on balancing exploration and exploitation overtime, which has advocated exploration–exploitation as a continuum, we regard exploration and exploitation as two distinct dimensions of learning activities, rather than as two ends of a unidimensional scale (Bierly & Daly, 2001; He & Wong, 2004; Katila & Ahuja, 2002).

2.2 The Exploration and Exploitation and its Effect on Innovation Performance

Given the fact that some empirical research has demonstrated the positive performance impacts of the joint pursuit of exploration and exploitation (e.g. ambidexterity) (Gibson & Birkinshaw, 2004; He & Wong, 2004; Lubatkin, Simsek, Ling, & Veiga, 2006), this does not mean that exploration or exploitation necessary guarantee performance (Sirén, Kohtamäki, & Kuckertz, 2012). It is still open to debate whether performance advantage accrues more to firms that balance exploitation and exploration or to those that focus on only one of these objectives (Sirén et al., 2012). As the nature of ambidexterity-performance relationship already draw extant attention in recent research (Gupta et al., 2006) less attention is paid on the relationship between performance and the separate dimensions of balance, namely exploration and exploitation, which broadly fits in above mentioned assumptions.

Exploitation activities can improve effectiveness and efficiency of existing core capabilities, which can lead to positive short-term effects (Belderbos, Faems, Leten, & Looy, 2010).

Both exploration and exploitation have been shown to positively affect organisational performance (Hernández-Espallardo, Sánchez-Pérez, & Segovia-López, 2011). To fully understand the performance implications of balancing exploration and exploitation, Stettner and Lavie (2013) consider the various levels of analysis (e.g., modes) via which a firm pursues these activities. They posit that exploring via externally oriented modes such as alliances, while exploiting via internal organization, enhances firms' performance. Hence, exploration improves performance as the firm distances itself from its core competencies (Stettner & Lavie, 2013). As the main objectives of our study are externally oriented mode (i.e. alliances) we hypothesizes that exploration-oriented alliances will benefit and consequently reap better innovation performance. Conversely, exploitation alliances relate to the enhancement of existing competencies, and benefit form clear and short-term performance objectives (Faems et al., 2005) which in turn is more beneficial for internal organizations which is not case in our study.

To further examine the mechanisms through which exploration-exploration, and hence ambidexterity influences performance Junni and colleagues (2013) recommend the use of more fine-grained performance measures such as innovation performance. Scholars generally agree that both activities as independent dimensions of strategic importance affect performance (Gupta et al., 2006). Firms need to invest considerable resources to develop exploration (de Leeuw, Lokshin, & Duysters, 2014). Thus, exploration in alliances have high levels of uncertainty, albeit potential gains of such explorations are high (de Leeuw et al., 2014). At the light of these differences, we contend that inter-organizational collaborations should have a more positive impact on innovation performance when firms develop explorative products/services than when they develop exploitative ones. While exploitation inhibits returns that are positive, proximate, and predictable, explorations ones are uncertain, often hi-risk, but potentially high-reward (March, 1991). Explorative activities can give firm an ability to cope with changing environments, open up new business opportunities and thus produce new products that differ significantly from the existing ones (Levinthal & March, 1993; March, 1991), which potentially are important to harvest long-term gains.

We thus hypothesize that the firm with more exploratory oriented alliances will be rewarded with higher innovation outcomes. Given the uncertain nature of exploratory activities, subsequently, firms face with of presence or absence of exploratory breakthroughs. We argue that performance effect of these exploratory breakthroughs performance has the force of overwriting the negative implications of the past unsuccessful exploratory activities. To sum up, one successful radical innovation exploration alliances can neutralize more unsuccessful ones, and conversely gain superb innovation gains. Moreover, due to organizational impediments such as conflicting routines, and negative transfer of learning that are firms exposed when simultaneously explore and exploit in a particular level of analysis such as via alliances, are likely to hamper the benefits of balance, and conversely lead to diminishing its performance (Stettner & Lavie, 2013). For instance, a firm that form technological alliances and acquire knowledge from their alliance partners for the aim of creation of new products and technologies can harvest benefits of balance by internally developing new advertising and distribution channels for already existing and to market known products. Hence, resources furnished via exploration in one level of analysis can facilitate exploitation in another level of analysis (Rothaermel, 2001). Furthermore, there is no resource spillover and firms can experience enjoyment benefits of specialization by concentration in one level of analysis and focusing on another one, which conversely enhances performance (Stettner & Lavie, 2013). Thus, the consequences from negative learning transfer can be avoided and firms can

simultaneously retain synergies of balance and specialization. We propose maximum performance benefits accrue at different levels of analysis. In such contexts, by employing specialization it allows us that firms can benefit from a balance between exploration and exploitation. Based on assumption that exploration and exploitation are disitinct activities, we propose a positive relationship between exploratory-oriented alliances and innovation performance.

H1a: Exploration is positively related to firm's innovation performance.

In the following, we will hypothesize that exploitative alliances will generate smaller impact on its firm's innovation outcome. Exploitation alliances could face with dual task because they are simultaneously striving to leverage firm's existing capabilities and combines competencies across organizational boundaries (Rothaermel & Deeds, 2004), which might lead to perceived rewards in the form of improved production process or distribution method, or support activity for goods or services (O'Reilly & Tushman, 2008) which are typically associated with striving for "downstream innovative performance" (Nielsen & Gudergan, 2012). As a consequence these outputs are important to harvest short-term efficiency (March, 1991). Although both activities can create positive synergies, they compete for limited resources within each partner firm (Yang, Zheng, & Zhao, 2014). This is particularly important because firms today often lack sufficient resources to afford both alliance strategies (Lin, Yang, & Demirkan, 2007). In alliance context, these task seems challenging and overwhelming because they are simultaneously forming an exploitative alliance to capitalize on complementary assets between partner firms (Yang et al., 2014), and on the other hand to discover new opportunities with the aim of building new competencies and adapting to the environment (Koza & Lewin, 1998) to form an exploratory one. Thus, firm's performance varies with the configuration of exploration and exploitation activities within and across the different levels of analysis (Stettner & Lavie, 2013).

Moreover, due to their basic incompatible nature (March, 1991) they require substantially different processes, structures, cultures and capabilities, and conversely affect performance differently (He & Wong, 2004; O'Reilly & Tushman, 2008; Raisch & Birkinshaw, 2008). Nielsen and Gudergan (2012) argued that exploration and exploitation in the context of strategic alliances (i.e. exploration and exploitation fit) as fundamentally different firms objectives and intentions result in different outcomes. For instance, engagement in exploitative activities are typically associated with quality improvements, cost and time savings, and productivity gains (Baer & Frese, 2003; Klomp & Van Leeuwen, 2001) might not be a necessary condition for achieving substantial performance improvements. While we theorize that positive performance implication of balancing exploitation and exploration activities is welcomed, we also argue that this necessary cannot be true for within one level of analyses. The firm that pursue both exploration and exploitation activities within one particular level of analysis cannot follow persistent patterns of behavior that are essential for effective use of its routines. The inconsistency between exploration and exploitation routines is likely to persist because of the self-reinforcing nature of these activities (Levinthal & March, 1993). Exploitation via alliances cannot rely exclusively on the firm's established knowledge (Stettner & Lavie, 2013). This limits the firm's ability to fully benefit from the reliability, stability, and productivity associated with its established knowledge (Stettner & Lavie, 2013). Thus, the alliance activity makes the firm vulnerable to exploitation. For instance, sharing alliance-related knowledge with others may result in indirect knowledge spillover (Arend, Patel, & Dennis Park, 2013), what can in turn hamper innovation performance. In summary, we hypothesize that:

H1b: Exploitation is negatively related to firm's innovation performance.

3 Methods

3.1 Measures

We used CIS 2006 micro data (company level) for the main explanatory variables and control measures. Anonymized data for the following countries were available and obtained centrally via Eurostat: Bulgaria, Cyprus, Czech Republic, Estonia, Norway, Portugal, Romania, United Kingdom, Slovakia, Slovenia, Spain and Switzerland.

Exploration. Each alliance (respectively, 25595) was classified as either exploration or exploitation. In order to measure exploration and exploitation at the alliance level, we adopted a scale from Tushman and O'Reilly (1996). This scale is built on original (March, 1991) thoughts' which in a very broad manner operationalize exploration and exploitation activities, but they have been apply it more narrowly and to innovation context. To operationalize exploration in the alliance context we used questions from the Community Innovation Survey (CIS). After asking managers to define if their firm introduced new or improved products or services in the previous two years (2004-2006), we used those firms who indicated that having one or both product innovations and we take into account only those firms who developed these product innovations with or mainly with other firms or institution or within enterprise group. We used similar approach as (Blindenbach-Driessen & Ende, 2014)_ENREF_7. Exploration is a measure equal to 0 if the firm reports that have not developed any innovations, value 2 if firm has innovation in both categories, and value 1 if reports only in one category.

Exploitation. The CIS data contains information about three types of innovations related to process improvements: new or improved methods of manufacturing, logistics or distribution, or supporting systems for goods or services. In line with Blindenbach-Driessen and Ende (2014), exploitation in the alliance context is coded as: if the alliance reports to have innovations in all three categories, exploitation has the value 2, and if the alliance reports to have innovation in one or two of the categories, exploitation has the value 1. The analysis is confined to firms engaging in exploitation and/or exploration.

Firms Innovation Performance. To operationalize alliance innovation performance, we follow the approach of previous studies that have conceptualized this variable using CIS data (Blindenbach-Driessen & Ende, 2014; Laursen & Salter, 2006; Oerlemans, Knoben, & Pretorius, 2013). Innovation performance is operationalized with one combined measure through which firm were asked to indicate the percentage of turnover introduced during 2004 to 2006 that is attributable to (1) products and services that are totally new-to-the-firm and (2) products and services that are new new-to-the-market. Originally, CIS question combines two latter categories and one more – products that stayed the same or had only minor modifications over the period 2004–2006. We believe that latter two categories capture essence of innovative performance, so we excluded this category from research. Furthermore, definitions of exploration and exploitation were included just before this CIS question to make sure that respondents interpret these categories in the same way and to improve construct validity (de Leeuw et al., 2014)

We included several *control variables* in the analysis. Firm size was used as a control variable. It is calculated as the logarithm of the number of employees in 2006. We also included count variable that measures the number of factors hampering firm's innovation activities. These hampering factors to innovation were included in recent work by de Leeuw et al. (2013) as resource constraints or Oerlemans et al. (2013) as different types of bottlenecks to innovation. "Lack of quality personnel", or "lack of financial resources" are one of eleven possible hampering factors measured on four-degree importance scale ("high",

"medium", "low" and "no effect"). An additive measure is used, the same one used by Černe, Jaklič, and Škerlavaj (2013). We cannot compare firms from different industries, given that different industries have different possibilities to innovate. We control for differences between five NACE sectors. Following Černe et al. (2013) we dummy coded firms as "batch manufacturing," "assembly manufacturing," "construction and utilities," "professional and financial service", and "other services". In line with Černe et al. (2013), geographic scope is operationalized as local (0), regional (1), national (2), or international (3). The variable R&D intensity is calculated by dividing the R&D expenditures by the turnover (Blindenbach-Driessen & Ende, 2014). Finally, we included *The Use of Codified External Information Sources*, because these sources provide firms with external information and/or knowledge and can influence innovative performance (Oerlemans et al., 2013). Control variable is calculated by taking the ratio of the total score and the maximum possible score (de Leeuw et al., 2014). Respondents were asked to rate on a scale of zero (not used) to three (very important) the extent they use three external information sources–patents, electronic information, and professional literature–for technological innovations.

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Innovation performance	0.27	0.36													
2	Firm size (log)	0.67	0.73	-0.05**												
3	Batch manufacturing	0.39	0.49	-0.04**	0.01											
4	Assembly manufacturing	0.19	0.39	0.05**	0.04**	-0.38**										
5	Construction and utilities	0.05	0.21	-0.02**	0.05**	-0.18**	-0.11**									
6	Other services	0.17	0.37	-0.05**	-0.05**	-0.36**	-0.22**	-0.10**								
7	Professional and financial services	0.17	0.38	0.05**	-0.03**	-0.36**	-0.22	-0.10	-0.20							
8	Geographic scope	2.32	0.77	-0.01*	0.15**	0.17**	0.18**	-0.19**	-0.11**	-0.12**						
9	Resource constraints	12.93	7.32	0.03**	-0.07**	0.07**	0.05**	-0.03**	-0.07**	-0.05**	0.06**					
10	R&D intensity	0.23	13.42	0.02**	0.00	0.00	0.00	0.00	-0.01	0.01	0.00	0.00				
11	Use of codified knowledge sources	0.35	0.22	0.06**	0.16**	0.02**	0.05**	-0.06**	-0.05**	0.03**	0.11**	0.19**	0.00			
12	Exploration	0.85	0.68	0.46**	0.07**	0.01*	0.09**	-0.08**	-0.09**	0.06**	0.11**	0.07**	0.00	0.26**		
13	Exploitation	0.92	0.58	-0.12**	0.16**	0.04**	0.00	-0.02**	0.00	-0.02**	0.06**	0.01	-0.01	0.21**	-0.02**	

[a] n = 25595.

$^{**}p < .01$, $^{*}p < .05$.

Table 1: Study 1 - Means, Standard Deviations, and Correlations [a]

3.2 Hierarchical regression analysis results

To test our hypothesis, we developed a set of models and tested them with multiple hierarchical linear regression analyses. First, we added exploration as a first predictor of innovation performance. The results show that exploitation is significantly and positively (thus, supporting Hypothesis 1b) related to innovation performance (model 2: b = .26, s.e. = .00, p <.01). Exploitation, second predictor in the model 2 was negatively but significantly related to innovation performance (model 2: b= -.08, s.e. = .00, p<.01). Therefore, Hypothesis 1a is not supported.

Variables	Innovation performance							
	Model 1				*Model 2*			
	b	*SE*	*β*	*t*	*b*	*SE*	*β*	*t*
Firm size (log)	-0.03**	0.00	-0.05	-8.38	-0.03**	0.00	-0.06	-10.01
Batch manufacturing	-0.02*	0.01	-0.02	-1.29	-0.06**	0.01	-0.08	-5.81
Assembly manufacturing	0.04**	0.01	0.05	3.33	-0.03*	0.01	-0.03	-2.78
Construction and utilities	-0.02	0.02	-0.01	-1.20	-0.02†	0.01	-0.01	-1.63
Other services	-0.04**	0.01	-0.04	-3.22	-0.06**	0.01	-0.07	-5.58
Professional and financial services	0.04**	0.01	0.04	3.01	-0.04**	0.01	-0.04	-3.12
Geographic scope	-0.01*	0.00	-0.02	-2.55	-0.02**	0.00	-0.04	-6.37
Resource constraints	0.00	0.00	0.01	1.96	0.00	0.00	0.00	0.28
R&D intensity	0.00**	0.00	0.02	3.06	0.00**	0.00	0.02	3.01
Use of codified knowledge sources	0.10**	0.01	0.06	9.04	-0.06**	0.01	-0.03	-5.50
Exploration					0.25**	0.00	0.47	81.55
Exploitation					-0.05**	0.00	-0.08	-14.80
R^2	0.01**				0.23**			
F (df)	37.34 (10, 25584)				634.12 (12 25582)			
ΔR^2	0.01				0.22			

[a] **p<.01, *p<.05, , †p<.1

Table 2: Hierarchical regression analyses for innovation performance as the dependent variable[a]

4 General Discussion and Conclusion

We contributed to the well-established research on balancing exploration and exploitation, by extending the separation approach (Stettner & Lavie, 2013). Our first theoretical contribution of our study addresses gaps in the exploration/exploitation literature. Our investigation revealed that the exploration activities via alliances positively affect the firm's innovation performance, but this is not the case for exploitation, and thus advance ambidexterity research by asserting that balance within one level of analysis (portfolio) attenuates performance more than balance across different levels of analysis (Stettner & Lavie, 2013). By contributing to further advancing the exploration-exploitation framework in cross-national firms, we also make a contribution to the international management literature. As the large portion of our sample consists of international alliances (CIS 2006 micro data: Bulgaria, Cyprus, Czech Republic, Estonia, Norway, Portugal, Romania, United Kingdom, Slovakia, Slovenia, Spain and Switzerland) we contribute to the understanding the exploration-exploitation tensions in alliances along mix of different industries and national contexts.

The result of multiple regression analysis suggests that relationship between exploration activities and exploitation activities via alliances and innovation performance differ. The results reveal a positive relationship between exploration and innovation performance. Contrary, this is not a case for exploitation. Essentially our study informs alliance managers whether specific alliance type, exploration or exploitation is most beneficial to undertake. With regard to former, firms should first carefully monitor their alliance motivation. Our findings show that firms can enhance its performance by expending knowledge base via alliances. Specifically, it is more beneficial to align with external exploration when seeking new knowledge, while the existing knowledge i.e. exploitation leverage internally. To sum up, alliance managers might be introduced with the notion that exploitation is not so rewarding within the interorganizational level. This coincides with Stettner and Lavie (2013) suggestions – that balancing across *different* levels is more beneficial, and that decoupling exploration from exploitation within level of analysis is recommended.

Our study shows that high levels of firm's exploration activities might be particularly valuable for alliance portfolios. This is particularly relevant for several reasons. First, a firm who favours balance of exploration and exploitation alliances are advised to pay extra attention when employing external knowledge. As first, external knowledge for different purpose, to exploit or explore can be overwhelming for firms. With regard to the latter, for exploitation alliances external and diverse knowledge can hamper or does not add much to firm's innovation performance. As, such redesigning alliance portfolio continuously (de Leeuw et al., 2014) might help alliance mangers to improve their performance outcomes. Further research could overcome these issues by further empirically validate optimal configuration for firms balancing exploration externally, while exploiting internally or vice versa. Although CIS data might be of doubtful quality in terms of accuracy of exploration and exploitation activities assessment, it leaves a room for further research. Although CIS data may have their shortcomings, they are well accepted by different scholars in exploration/exploitation research.

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Income Efficiency of Slovenian Public Institutions in the Field of Culture: A Data Envelopment Analysis Approach

Andrej Srakar
Institute for Economic Research, Ljubljana and Faculty of Economics, University of Ljubljana, Slovenia
andrej.srakar@ier.si

Anela Bešo
Društvo Asociacija, Ljubljana, Slovenia
anela.beso@asociacija.si

Abstract

In Slovenia, the reform of the public sector in culture has been widely debated in the past years. Yet, so far no study has been made to empirically estimate whether the institutions are efficient and where are the key empirical problems in their efficiency. Our study addresses this void by using data envelopment analysis approach with bootstrap correction to estimate the income efficiency of public institutions in the field of culture. Our results show that although income efficiency of public institutions in culture was dropping in past few years, there is no statistical evidence that they were indeed income-inefficient. We identify the key institutions that were most income-efficient and income-inefficient and, finally, explore the characteristics most influencing the income efficiency. We conclude by policy reflection of the findings and suggestions for future research.

Keywords: public institutions, culture, statistical indicators, income efficiency, DEA analysis

1 Introduction

In Slovenia, the field of the reform of public sector in culture and the arts has been widely debated in the past decade, particularly after the former minister of culture, Mrs. Majda Širca, agreed to implement the working groups for structured dialogue in culture in Slovenian practice, following the commonly accepted practice on the level of the European Union. Furthermore, she formed

the expert group for modernization of the public sector, which to date presented three proposals, one in the mandate of each minister: in 2011 under minister Širca, in 2012 under minister Turk, and in 2014 under minister Grilc (an informal proposal, so far not presented in public discussion).

Despite proposals and discussion, so far no reliable (if any at all) empirical studies on the problems of public sector in culture have been presented. Our article, therefore, starts on this foundation and wants to present a first analysis of efficiency of public sector in general *and* of the individual public institutions. To this objective we use Data Envelopment Analysis as a

commonly accepted approach for the analysis of efficiency of public institutions in any sector of the public economy. Due to limited data, we present only the analysis of "income efficiency" by which me mean efficiency in achieving revenues of the public institution using the smallest amount of invested inputs. Other approaches and other types of efficiency could be used as well if having better data possibilities which will hopefully be done in future research.

Our article is, therefore, structured in the following way. In the next section, we present the data and used method. In the third section, we present results of DEA analysis of individual public institutions in culture. In the fourth section, we present results of aggregate efficiency of public sector in culture in years 2002-2011. In the fifth section, we present results of regression analysis of characteristics, influencing the efficiency of public institutions in culture in Slovenia. In the final section we conclude with discussion of findings and policy implications.

2 Data and method

In our analysis we use data from Ministry of Culture of Republic of Slovenia, kindly provided by the staff of the ministry. This of course limits the included institutions to only those that are, at least partly, financed by the ministry *on regular basis*. There are, therefore, 70 public institutions in our analysis, namely:

National (28) - SNG Theatre Ljubljana; SNG Maribor (theatre and opera); SNG Nova Gorica; Center for Contemporary Dance Arts (which formally existed only in the years 2011 and 2012); SNG Opera and Ballet Ljubljana; Slovenian Philharmonic Orchestra; National Gallery; Museum of Modern Art; Historical Archives of Ljubljana; Regional Archives Maribor; Historical Archives of Celje; Regional Archives of Nova Gorica; Regional Archives Koper; Historical Archives Ptuj; Institute for the Protection of Cultural Heritage of Slovenia; National Museum of Slovenia; Natural History Museum of Slovenia; Slovenian Ethnographic Museum; Museum of Contemporary History of Slovenia; Slovenian National Theatre Museum; Technical Museum of Slovenia; Slovenian Cinematheque; Museum of Architecture and Design; Slovenian Museum of Christianity; NUK; Cankarjev dom; Viba film; Volčji Potok Arboretum.

Municipal (42) - Slovenian National Theatre Celje; Ljubljana City Theatre; Slovenian Youth Theatre; Ljubljana Puppet Theatre; Maribor Puppet Theatre; Pilon Gallery Ajdovščina; Gallery Božidar Jakac; International Centre of Graphic Arts Ljubljana; Maribor Art Gallery; Gallery of Murska Sobota; The Coastal Galleries; Koroška Gallery of Fine Arts; Posavje Museum Brežice; Regional Museum Celje; Museum of Contemporary History Celje; Idrija Municipal Museum; Kamnik Municipal Museum; Regional Museum of Kočevje; Koper Regional Museum; Gorenjska Museum Kranj; City Museum of Ljubljana; Museum of National Liberation Maribor; The Regional Museum Maribor; Bela Krajina Museum Metlika; Pomurska Museum of Murska Sobota; Museum of Gorica; Dolenjska Museum Novo mesto; Maritime Museum Piran; Notranjska Museum; Regional Museum Ptuj-Ormož; Radovljica Municipality Museums; Koroška Regional Museum; Loka Museum; Zasavska Museum Trbovlje; Velenje Museum; Tolmin Museum; Upper-Sava Valley Museum Jesenice; Prešeren Theatre Kranj; Koper Theatre; Ptuj City Theatre; Anton Podbevšek Theatre Novo mesto; Ljutomer Museum.

The method we use is the method of Data Envelopment Analysis (DEA). The variables that we use in our analysis and were included in the initial dataset sent from the ministry are: total funds, provided to the public institution from the Ministry of Culture; total funds, provided to

the public institution from the local municipality; number of employees in the public institution; total revenues of a public institution; revenues from market sources; "other" revenues (revenues from tickets, sponsorships, donations, memberships, etc.). We calculate the income-effectiveness separately for each year in each public institution (calculations were therefore done separately for years). Income-effectiveness is calculated under the assumptions of constant returns to scale and orientation to the inputs (i.e. to achieve a given output with a minimum use of inputs). As inputs in a public institution, we use the total public expenditure (municipal and ministry funds) for the institution and the number of employees, while for the outputs we use three separate variables: total revenues of a public institution; revenues from market sources; "other" revenues (revenues from tickets, sponsorships, donations, memberships, etc.).

Because the sample is relatively small and for usage in latter regression analysis, we use bootstrap-corrected efficiencies following the method of Simar and Wilson (1998; 2000; 2007).

It is necessary, also, to mention some important methodological limitations: the calculation includes all public institutions in culture, funded by the Ministry of Culture, where the data exist. This brings two major problems: firstly, all those institutions with the number of employees equal to zero (e.g. Prešeren Theatre Kranj, Ptuj City Theatre, Theatre Koper, Anton Podbevšek Theatre, in 2011 also the Center for Contemporary Dance Arts) have, of course, excellent efficiency results as they managed to achieve their objectives with minimal staff requirements. For these reasons, those institutions are removed from most of the analysis.

Another problem is the comparison between the institutions themselves, as they operate in different areas of cultural sector. This problem is crucial, because, on one hand, this means the inclusion of institutions such as the Institute for Protection of Cultural Heritage, National University Library (NUK) and Volčji Potok Arboretum, while, on the other hand, it also means comparing the archives (which clearly do not have much revenues from market and other sources, by the very mission they serve) with theaters and galleries. Nevertheless, comparison of income-effectiveness (ability to generate revenue with limited resources) is related to all involved institutions and, with that in mind, we include archives and other similar institutions in our analysis despite this problem.

Some words about the method are also appropriate. DEA is a non-parametric statistical method (it presumes no particular statistical distribution of data), which has in recent decades become a very popular part of the analysis of the efficiency of public institutions. The method is built by adding two types of variables: inputs (in this case public funding and number of employees); and outputs/results (in our case the total revenues and income from our three sources). Efficiency is expressed on a scale from 0 to 1 or more, where 0 means complete inefficiency and 1 full effectiveness. The analysis is possible for the input-oriented model (when institutions seek to achieve the results with minimum inputs) or for the output-oriented model (where institutions are trying to achieve the maximum results with the given inputs). Analysis has become known in the field of cultural economics in particular related to the work of researchers at the University of Catania, especially with article by Cuccia, Guccio and Rizzo (2013). Other recent and notable articles in this area of cultural economics have been e.g. Zieba 2011; Guccio, Pignataro, Mazza & Rizzo 2014; Suominen 2014 and Herrero-Prieto & Gómez-Vega 2014.

3 Income efficiency of individual public institutions

In Table 1 we can see the efficiency coefficients (bootstrap adjusted) of top Slovenian institutions for years 2009, 2010, 2011, and on average in period 2002-2011 (our output variable for Table 1 and Table 2 was total revenues) From the results, excluded due to the above mentioned problems are Volčji Potok Arboretum (which is the first in all scales), and five institutions with zero staff: Prešeren Theatre Kranj, Ptuj City Theatre, Theatre Koper, Anton Podbevšek Theatre and Center for Contemporary Dance Arts. All of the mentioned institutions are also at the very top of the charts.

From the table, it appears clear that the most successful are the public institutions, relying a lot on private funds and audience development: Cankarjev dom, City Museum of Ljubljana, Ljubljana City Theatre. Very successful are also the Upper-Sava Valley Museum Jesenice, which with a relatively small staff creates a substantial amount of "other" revenues (for definition, see above). Similar is the story of the Regional Museum Kočevje, which has very few employees and a small annual budget, but nevertheless manages to create quite a good share of the "other" revenues and revenues at the market.

MOST EFFICIENT SLOVENIAN PUBLIC INSTITUTIONS IN CULTURE 2002-2011

2009			2010			2011			Total		
institution	efficiency	rank	institution	efficiency	rank	institution	efficiency	rank	institution	efficiency	rank
Cankarjev dom	0.5451	5	City Museum of Ljubljana	0.6697	6	Ljubljana City Theatre	0.6869	6	Cankarjev dom	0.6024	7
City Museum of Ljubljana	0.4422	6	Ljubljana City Theatre	0.5062	7	City Museum of Ljubljana	0.5651	8	POMURSKI MUZ. MURSKA SOBOTA	0.5242	8
Viba Film	0.3993	7	Upper-Sava Museum Jesenice	0.4554	8	Upper-Sava Museum Jesenice	0.5520	9	Upper-Sava Museum Jesenice	0.5037	9
Regional Museum of Kočevje	0.3833	8	Cankarjev dom	0.4222	9	Cankarjev dom	0.4035	10	City Museum of Ljubljana	0.4686	10
Zasavska Museum Trbovlje	0.3821	9	Regional Museum of Kočevje	0.3443	10	Tolmin Museum	0.3683	11	Institute for Protection of Cultural Heritage of Slovenia	0.4658	11
Regional Museum Ptuj-Ormož	0.3814	10	Viba Film	0.3267	11	Viba Film	0.3383	12	Slovenian Cinematheque	0.4480	12
Slovenian Cinematheque	0.3782	11	The Coastal Galleries	0.3188	12	Regional Museum of Kočevje	0.3289	13	Viba Film	0.4297	13
The Coastal Galleries	0.3731	12	Ljubljana Puppet Theatre	0.3003	13	Maribor Puppet Theatre	0.3276	14	Regional Museum of Kočevje	0.4294	14
Maribor Puppet Theatre	0.3699	13	Museum of Architecture and Design	0.2989	14	Slovenian Cinematheque	0.3270	15	Tolmin Museum	0.4283	15
Technical Museum of Slovenia	0.3699	14	Regional Museum Celje	0.2948	15	The Coastal Galleries	0.3166	16	The Coastal Galleries	0.4072	16

Table 1: Most efficient Slovenian public institutions in culture 2002-2011

In Table 2 below are the "underdogs", that is, the worst ranked public institutions. Expectedly, among them are predominantly archives (see above), yet, we can find among them also several museums: Koroška Regional Museum, Zasavska Museum Trbovlje, Posavje Museum Brežice, Koper Regional Museum and Kamnik Municipal Museum. Those institutions stand out either by a relatively large number of employees (between 10 and 20; as compared to their rather small size) or the relatively small proportion of funding from "other" or market sources. Clearly visible are the problems of the public institution SNG Opera and Ballet Ljubljana, which, interestingly, creates a pretty good share of funds from "other" sources, but it also has almost 300 employees and, compared with other institutions, very large budget in years 2010 and 2011, which reaches almost 11 million and is the second largest (behind only SNG Maribor (theatre and opera) among all institutions included in the analysis.

LEAST EFFICIENT SLOVENIAN PUBLIC INSTITUTIONS IN CULTURE 2002-2011

2009			2010			2011			Total		
institution	efficiency	rank	institution	efficiency	rank	institution	efficiency	rank	institution	efficiency	rank
Regional Archives Maribor	0.3059	57	Regional Archives Maribor	0.1946	59	Posavje Museum Brežice	0.2031	60	Koroška Regional Museum	0.2856	61
Museum of Contemporary History of Slovenia	0.3030	58	Kamnik Municipal Museum	0.1921	60	Gallery of Murska Sobota	0.2011	61	Zasavska Museum Trbovlje	0.2853	62
Koper Regional Museum	0.3021	59	Zasavska Museum Trbovlje	0.1920	61	Historical Archives of Celje	0.1993	62	Posavje Museum Brežice	0.2846	63
Velenje Museum	0.3004	60	Posavje Museum Brežice	0.1912	62	Zasavska Museum Trbovlje	0.1983	63	Koper Regional Museum	0.2822	64
Pilon Gallery Ajdovščina	0.2992	61	Slovenian National Theatre Celje	0.1866	63	SNG Opera and Ballet Ljubljana	0.1945	64	Kamnik Municipal Museum	0.2805	65
Regional Archives of Nova Gorica	0.2991	62	Regional Archives Koper	0.1822	64	Regional Archives Koper	0.1926	65	SNG Opera and Ballet Ljubljana	0.2653	66
Regional Archives Koper	0.2970	63	SNG Opera and Ballet Ljubljana	0.1785	65	Museum of National Liberation Maribor	0.1919	66	Regional Archives Koper	0.2627	67
Historical Archives of Ljubljana	0.2947	64	Historical Archives of Ljubljana	0.1769	66	Historical Archives of Ljubljana	0.1824	67	Historical Archives of Ljubljana	0.2591	68
Koroška Gallery of Fine Arts	0.2942	65	Regional Archives of Nova Gorica	0.1666	67	Regional Archives of Nova Gorica	0.1758	68	Regional Archives of Nova Gorica	0.2532	69
Historical Archives Ptuj;	0.2928	66	Historical Archives Ptuj;	0.1614	68	Historical Archives Ptuj;	0.1723	69	Historical Archives Ptuj;	0.2483	70

Table 2: Least efficient Slovenian public institutions in culture 2002-2011

4 Aggregate income efficiency of public sector in culture 2002-2011

A commonly heard claim in Slovenian media is that public institutions are inefficient (see e.g. SiOL 2014). No different is the situation with discussions about (in)efficiency of public sector in culture (for explanations see e.g. Smrekar, Rotovnik & Čopič 2013).

Therefore, an obvious challenge for our analysis is to test the validity of such claims on our dataset. To this end, we add up the data on all public institutions for each year, and then repeat the same process of (bootstrap-corrected) DEA analysis, except that the units are in this case the years; we therefore have 10 units: 2002; 2003; 2004; 2005; 2006; 2007; 2008; 2009; 2010; and 2011. To get consistent estimates of the parameters in this case, bootstrap is not only desirable but necessary and we carry out the same methodological procedure as in the previous section. Estimates are, despite the small sample, sufficiently consistent, which is shown by the values of statistical significance (well-known p-values) which are for all calculated efficiencies strongly statistically significant.

The results below are presented for three separate model-based specifications: the first use total revenues as output variable; the second “other” revenues; and the third the revenues from market sources.

The results in Table 3 are quite clear. The overall income-efficiency of public institutions in culture in 2007-2009 was still relatively good, but especially in the years 2010 and 2011 declined sharply. This drop is present both in the efficiency of obtaining "other” as well as market revenues. Even the overall efficiency shows decline over the years, but is still above the limit of efficiency. We, therefore, cannot fully confirm that public institutions in culture were inefficient in the period 2002-2011, but they were (and are) obviously becoming less and less efficient when it comes to obtaining funds from “other” and market revenues.

It's worth noting that the aggregated analysis excludes all institutions, excluded also in the analysis of the previous section (Volčji Potok Arboretum, Prešeren Theatre Kranj, Ptuj City Theatre, Theatre Koper, Anton Podbevšek Theatre, Center for Contemporary Dance Arts).

	1st specification: total revenues		2nd specification: "other" revenues		3rd specification: market revenues	
	efficiency	rank	efficiency	rank	efficiency	rank
Year 2002	1.0569	3	1.3697	2	1.1628	4
Year 2003	0.9972	9	0.8534	8	1.2944	2
Year 2004	0.9841	10	0.9877	5	1.3911	1
Year 2005	1.0622	2	1.4114	1	1.0019	7
Year 2006	1.0166	8	0.8712	7	0.7414	10
Year 2007	1.0242	7	1.1113	3	1.1791	3
Year 2008	1.0448	5	0.9355	6	1.0141	6
Year 2009	1.0710	1	1.0219	4	1.1420	5
Year 2010	1.0552	4	0.8256	9	0.9537	8
Year 2011	1.0381	6	0.8029	10	0.9034	9

Table 3: Aggregate income efficiency of public sector in culture 2002-2011

5 Characteristics, most influencing income efficiency of public institutions in culture

In the last part of the analysis verify which external variables have the most impact on the calculated efficiency scores. We include six additional variables:

- a linear time trend;
- nationalocal: a dummy variable, having value of 1 if the institution is a national public institution and 0 if it is a local public institution;
- LJnonLJ: a dummy variable, having value of 1 if the institution is based in Ljubljana, and 0 otherwise;
- culture: number of visitors to local museums, galleries and cultural centres (source of data: Statistical Office of Republic of Slovenia – SORS);
- motorways: kilometres of local roads per 1,000 square kilometres (source of data: SORS);
- theft: convicted persons in neighbourhood per 1,000 inhabitants (source of data: SORS)

The last three variables are included following the analysis of Cuccia, Guccio and Rizzo (2013). Model I evaluates the relationships by random effects linear panel estimator (of course we are dealing with unbalanced data, due to missing observations), while Model II uses a "system" generalized method of moments estimator (following Arellano and Bover (1995) and Blundell and Bond (1998)), suitable for dynamic analysis.

The results in Table 4 below are shown for first dependent variable, the bootstrap-corrected efficiency scores, separately for each of the two estimators. The results in Table 5 are, on the other hand, shown for the dependent variable of ranks among institutions, based on efficiency scores. Again, this is shown separately for each estimator.

Results of Table 4 clearly show that: 1) Efficiency scores are significantly and negatively correlated with the time trend, which means that efficiency of public institutions in culture was indeed (on average) falling over the period 2002-2011; 2) the efficiency of the national institutions is on average smaller than efficiency of the local public institutions; 3) there was no significant difference between Ljubljana-based and non-Ljubljana-based institutions; 4) among other variables, visitors of cultural institutions and development of local infrastructure significantly and positively contribute to efficiency of public institutions in culture.

dependent variable: efficiency	Panel random effects model		System GMM model	
Variables	Coefficient [Std. Error]	Sig	Coefficient [Std. Error]	Sig
y(-1)			0.2414	
			[0.0415]	***
y(-2)			-0.0710	
			[0.0428]	*
y(-3)			-0.4270	
			[0.0561]	***
constant	0.4386		0.9319	
	[0.0250]	***	[0.0575]	***
time trend	-0.0073		-0.0084	
	[0.0011]	***	[0.0017]	***
nationalocal	-0.0417		-0.5270	
	[0.0355]		[0.0785]	***
LJnonLJ	0.0051		0.0007	
	[0.0446]		[0.0463]	
Culture	0.9861		0.6763	
	[0.0036]	***	[0.2309]	***
Motorways	-0.0375		0.0257	
	[0.0293]		[0.0093]	**
Theft	0.0538		0.0001	
	[0.0497]		[0.0005]	
Observations	660		456	
Wald chi	46.71	***	451.20	***

Table 4: Regression models, dependent variable: efficiency

On the other hand, results of Table 5 clearly show that: 1) The coefficient on time trend is again significant and negative; 2) the rankings of the national institutions are on average smaller than rankings of the local public institutions; 3) there is no consistent and significant difference between Ljubljana-based and non-Ljubljana-based institutions, although there is slight evidence from Model I that Ljubljana-based institutions are ranked higher; 4) among other variables, again, visitors of cultural institutions and development of local infrastructure significantly and positively contribute to rankings of public institutions in culture.

dependent variable: rank	Panel random effects model		System GMM model	
Variables	Coefficient [Std. Error]	Sig	Coefficient [Std. Error]	Sig
y(-1)			0.0757	
			[0.0721]	
y(-2)			-0.0991	
			[0.0647]	
y(-3)			-0.1219	
			[0.0606]	**
constant	68.3929		98.2663	
	[2.6156]	***	[12.4906]	***
time trend	-0.2996		-0.4658	
	[0.1166]	**	[0.1974]	**
nationalocal	-6.8865		-34.4809	
	[3.7189]	*	[8.3091]	***
LJnonLJ	9.1891		-16.6439	
	[4.6637]	**	[14.7785]	
Culture	12.2062		24.5398	
	[4.9532]	***	[8.2560]	***
Motorways	4.6352		4.9163	
	[2.5345]	**	[2.5002]	**
Theft	3.5664		1.0003	
	[3.2046]		[1.4300]	
Observations	660		456	
Wald chi	12.40	***	51.04	***

Table 5: Regression models, dependent variable: rank

6 Conclusion

In conclusion, let's firstly repeat the main findings of our analysis:

- Most efficient were public institutions, relying a lot on private funds and audience development: Cankarjev dom, City Museum of Ljubljana, Ljubljana City Theatre. Very successful were also some smaller local institutions: Upper-Sava Valley Museum Jesenice and Regional Museum Kočevje, mainly due to relatively low number of staff and low budget.
- Among the worst scoring institutions were predominantly archives, yet, there were also several museums: Koroška Regional Museum, Zasavska Museum Trbovlje, Posavje Museum Brežice, Koper Regional Museum and Kamnik Municipal Museum. Clearly visible are also the problems of the SNG Opera and Ballet Ljubljana.
- We cannot fully confirm that public institutions in culture were inefficient in the period 2002-2011, but they were (and are) obviously becoming less and less efficient when it comes to obtaining funds from "other" and market revenues.
- Regression analysis shows that efficiency of public institutions in culture was indeed (on average) falling over the period 2002-2011; the efficiency of the national institutions was on average smaller than efficiency of the local public institutions; there was no significant difference between Ljubljana-based and non-Ljubljana-based

institutions; visitors of cultural institutions and development of local infrastructure significantly and positively contributed to efficiency of public institutions in culture.

At the end, we can again refer to the attempts of public sector reforms in culture. Empirical analysis and evidence-based policy decisions are a necessity in contemporary policy design yet go largely unheard in Slovenian policy decision making (which is valid not just for the field of culture). Our analysis brings some empirical and statistical evidence in the area of public sector efficiency in the field of culture and slightly confirms the thesis on growing inefficiency in public sector in culture, particularly related to the raising of non-regular public revenues (we named these "other" and market revenues). We also point to some main institutions which are problematic and also to those that score the best. It is the task of policy decision-makers to support our findings with more evidence and on the basis of this, decide on the measures, necessary for development and efficiency of Slovenian public sector in culture. Indeed, the need for such approach to problems in Slovenia is dire and we hope our analysis will contribute a slight step in this direction.

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Designing Supply Chains for Maximal Expected Profit by the P-Graph Framework

Zoltán Süle
University of Pannonia, Department of Computer Science and Systems Technology, Hungary
sule@dcs.uni-pannon.hu

Éva König
University of Pannonia, Department of Computer Science and Systems Technology, Hungary
konig@dcs.uni-pannon.hu

János Baumgartner
University of Pannonia, Department of Computer Science and Systems Technology, Hungary
baumgartner@dcs.uni-pannon.hu

Abstract

Rapidly changing prices and taxes, as well as emerging new products and technologies, demand that the design of any company's supply chain has to be frequently revised to stay competitive. Mathematical modeling and optimization provide a solid basis for evaluating alternative designs and scenarios, reducing cost, improving efficiency, and adapting to changing requirements. Our work reveals a methodology that provides an adequate basis to portray and model supply chains mathematically and formally as well as to synthesize optimal and alternative supply scenarios algorithmically. The proposed methodology is based on the combinatorial foundations of algorithmic process synthesis or more specifically on the P-graph framework. A biodiesel supply network involving blending and transportation serves as an illustrative example. A novel algorithm generates the mathematical model and alternative solutions of supply scenarios as well as to determine the expected profit based on uncertainty.

Keywords: Supply Chains, P-graph Methodology, Optimization, Uncertainty, Expected Profit

1 Introduction

Transportation of goods is one of the most important parts of a supply chain management problem. Since the costs of the transportation can account for up to 50% of a product's total logistics costs (Bauer, 2002), finding the most effective way to satisfy the requirements is a major factor for an oil company to be able to maintain competitive advantages. There are several aspects in decision making: the solutions with optimal cost, with greatest profit or with highest reliability might need different strategies.

In the last decades, several robust and reliable process network optimization algorithms and software have been developed and implemented on the basis of the P-graph framework, e.g., Algorithm SSG (Friedler et al., 1995), Algorithm ABB (Friedler et al., 1996), Software PNS-Studio (Bertok et al., 2013a, 2013b). The approach based on the P-graph framework appears to be the only one being capable of generating mathematical model automatically, and providing the *n*-best networks for process synthesis. Moreover, all steps involved are mathematically proven, comprising superstructure generation, construction of the mathematical model, optimization, and the solution interpretation.

2 Methodology

The optimal design of supply chain under uncertainties is carried out via the P-graph based methodology. The mixed integer linear programming (MILP) problem, generated automatically via the algorithms of the method, serves as an input to subsequent optimization to determine optimal supply chain in terms of multiple criteria, e.g., cost-optimal, performance optimal given a cost limit, etc.

The problem definition contains the materials (raw materials, intermediates and products) and the operating units. The conventional directed/undirected graphs are inappropriate for process synthesis: the representation of the relationships between the operating units and the materials is ambiguous. In contrast, the process graph, or P-graph, is a directed bipartite graph that mathematically takes into consideration the combinatorial nature of process structures.

Let M be a finite set (material species), and let set $O \subseteq \Omega(M) \times \Omega(M)$ (operating units) with $M \cap O = \emptyset$, where $\Omega(M)$ denotes the power set of M. Pair (M, O) is defined to be a P-graph with vertex set $M \cup O$ and arc set $A = A_1 \cup A_2$, where $A_1 = \{(x, Y): Y = (\alpha, \beta) \in O, x \in \alpha\}$ and $A_2 = \{(Y, z): Y = (\alpha, \beta) \in O, z \in \beta\}$. If $(\alpha, \beta) \in O$, then set α and set β are called the input-set and output-set of (α, β) respectively.

In the P-graph framework, algorithm MSG produces the maximal structure, i.e., the superstructure for the PNS problem (Friedler et al., 1993). This maximal structure serves as the input to the generation and solution of the mathematical model by algorithm ABB (Friedler et al., 1996).

Algorithms MSG, SSG and ABB are collectively executed by software PNS Studio (Varga et al., 1995; p-graph.com, 2015). For each problem, PNS Studio constructs a mathematical model via algorithm MSG, which is solved by an accelerated branch-and-bound algorithm, i.e., algorithm ABB. The model contains constraints for the operating units and the materials. Capacities of the operating units, consumption of the raw materials, and production of the final products are bounded. Moreover, mass conservation laws are defined for the intermediates and final products. The aim is either to identify the least expensive feasible structure or to maximize the profit. If the cost of an operation is defined by a stepwise linear function of its mass load, both the constraints and the objective function can be described by linear expressions. Alternatively, PNS Studio can exhaustively enumerate each combinatorially feasible structure via algorithm SSG.

Algorithm ABB gives the optimal structure of a process network where the uncertainties of operating units are not taken into account. However, the optimal structure can be modified significantly because of the uncertainty of activities. Before making a decision and follow a strategy defined by one of the solution structures, the expected cost and/or profit can provide useful information about the behavior of the selected structure. In order to give the expected profit of a feasible solution it is needed to identify all the solutions that are feasible and subgraphs of the maximal structure. A sub-graph defines a feasible network, which is able to

fulfill the requirements using the operating units and materials of the maximal structure (all or some of them).

The probability of the occurrence of these sub-solutions can be calculated easily, since the failures of the activities are considered independent. In this case, we consider that the operating unit is either available with the certain capacity or not available at all. Besides it is possible to sell less from the product than it is produced.

The enumerating tree of a hypothetical network consists of only two operating units can be seen in Figure 1. Let the probability of malfunction of O1 and O2 be p and q, respectively. Then the probabilities of occurrence of S1, S2, S3 and S4 are $(1-p)\times(1-q)$, $(1-p)\times q$, $p\times(1-q)$ and $p\times q$.

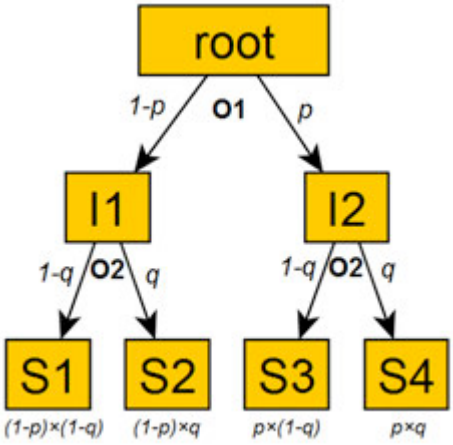

Figure 1: Enumerating tree describing the decisions about two operating units

Supposing that the profit of these structures is $profit_1, profit_2, profit_3$ and $profit_4$ then the expected profit of the considered scenario is:

$$profit_1\times(1-p)\times(1-q)+profit_2\times(1-p)\times q+$$
$$+profit_3\times p\times(1-q)+profit_4\times p\times q$$

The present method can be useful in solving short-term problems.

The next chapter introduces a case study where the cost and profit optimum, as well as the expected profit will be determined.

3 Case Study

An oil company operates plants at four locations which are cities of Százhalombatta, Komárom, Bratislava, and Korneuburg. The task to be performed is to satisfy bio-diesel demands of the company's plant in Korneuburg from the other three locations with minimal cost. A limited amount of bio-diesel and its components are available in Százhalombatta, Komárom and Bratislava. In Százhalombatta and Bratislava, a limited capacity for blending bio-diesel from the available components can be taken into consideration as well consuming the four main components of bio-diesel: the HDS gasoline (K2), the kerosene (K4), the K7

component (gasoline without sulfur), and the FAME bio-component (K8). The bio-diesel can be uploaded at any plants, transported to a target location by barge, and finally downloaded. All of the plants have upper bounds on their available resources. 1100 tons of biodiesel is available in Százhalombatta, 800 tons in Komárom and 900 tons in Bratislava. The plant in Százhalombatta and Bratislava can be produce maximum of 700 and 200 tons bio-diesel by blending. Table 1, 2 and 3 show the parameters of raw materials and product, as well as the properties of the activities.

Table 1: Parameters of raw materials

Name	Maximum available flow (t/yr)	Cost (€/yr)
Bio-Diesel in Bratislava Depot	900	790
K2 in Bratislava	200	700
K4 in Bratislava	200	715
K7 in Bratislava	200	715
K8 in Bratislava	200	1300
Bio-Diesel in Százhalombatta Depot	1100	840
K2 in Százhalombatta	700	700
K4 in Százhalombatta	700	715
K7 in Százhalombatta	700	715
K8 in Százhalombatta	700	1300
Bio-Diesel in Komárom Depot	800	780

Table 2: Parameters of product

Name	Required flow (t/yr)	Profit (€/yr)
Bio-Diesel in Korneuburg	2500	1000

Table 3: Parameters of activities

Activities	Inputs	Outputs	Capacity (t/yr)	Fix cost (€/yr)	Proporti-onal cost (€/yr)	Reliability
Blending (B1)	K2, K4, K7 and K8 components in Bratislava	Bio-Diesel blended in Bratislava	200	4600	5	r_{B1}=96%
Blending (B2)	K2, K4, K7 and K8 components in Százhalombatta	Bio-Diesel blended in Százhalombatta	700	5000	5	r_{B2}=98%
Upload1 (U1)	Bio-Diesel in Bratislava Depot	Bio-Diesel in barge in Bratislava	1200	20	0.1	r_{U1}=97%
Upload 2 (U2)	Bio-Diesel blended in Bratislava	Bio-Diesel in barge in Bratislava	2000	20	0.1	r_{U2}=97%
Upload 3 (U3)	Bio-Diesel in Komárom Depot	Bio-Diesel in barge in Komárom	2000	50	0.05	r_{U3}=97%
Upload 4 (U4)	Bio-Diesel in Százhalombatta Depot	Bio-Diesel in barge in Százhalombatta	1200	30	0.15	r_{U4}=98%
Upload 5 (U5)	Bio-Diesel blended in Százhalombatta	Bio-Diesel in barge in Százhalombatta	2000	40	0.2	r_{U5}=98%
Transport 1 (T1)	Bio-Diesel in barge in Bratislava	Bio-Diesel in barge in Korneuburg	1400	3500	3	r_{T1}=98%
Transport 2 (T2)	Bio-Diesel in barge in Komárom	Bio-Diesel in barge in Korneuburg	1200	4000	7	r_{T2}=96%
Transport 3 (T3)	Bio-Diesel in barge in Százhalombatta	Bio-Diesel in barge in Korneuburg	1600	8000	5	r_{T3}=97%
Download (D)	Bio-Diesel in barge in Korneuburg	Bio-Diesel in Korneuburg	2900	55	0.0643	r_{D}=99%

Figure 2 depicts the maximal structure for the illustrative example. The Algorithm SSG finds 31 alternative combinatorially feasible solution structures.

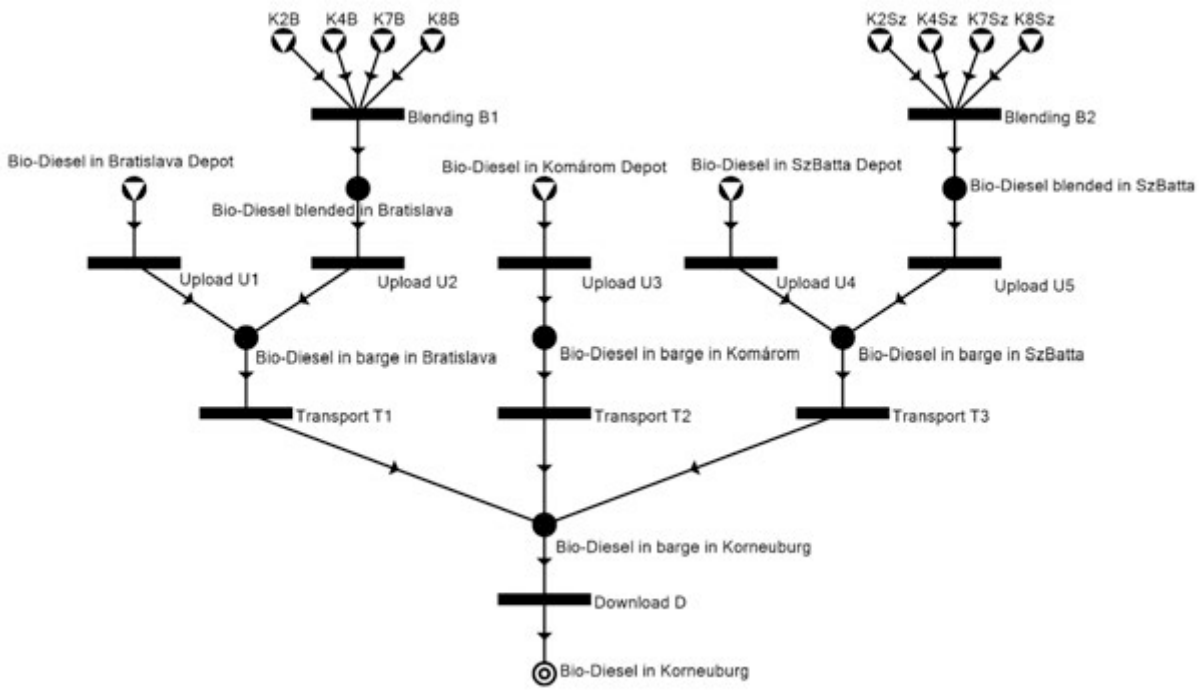

Figure 2: The maximal structure of the Bio-Diesel transportation problem

First, the cost optimal solution was calculated with Algorithm ABB, which means that the price of the product is zero. Figure 3 represents the structure of the cost optimal solution.

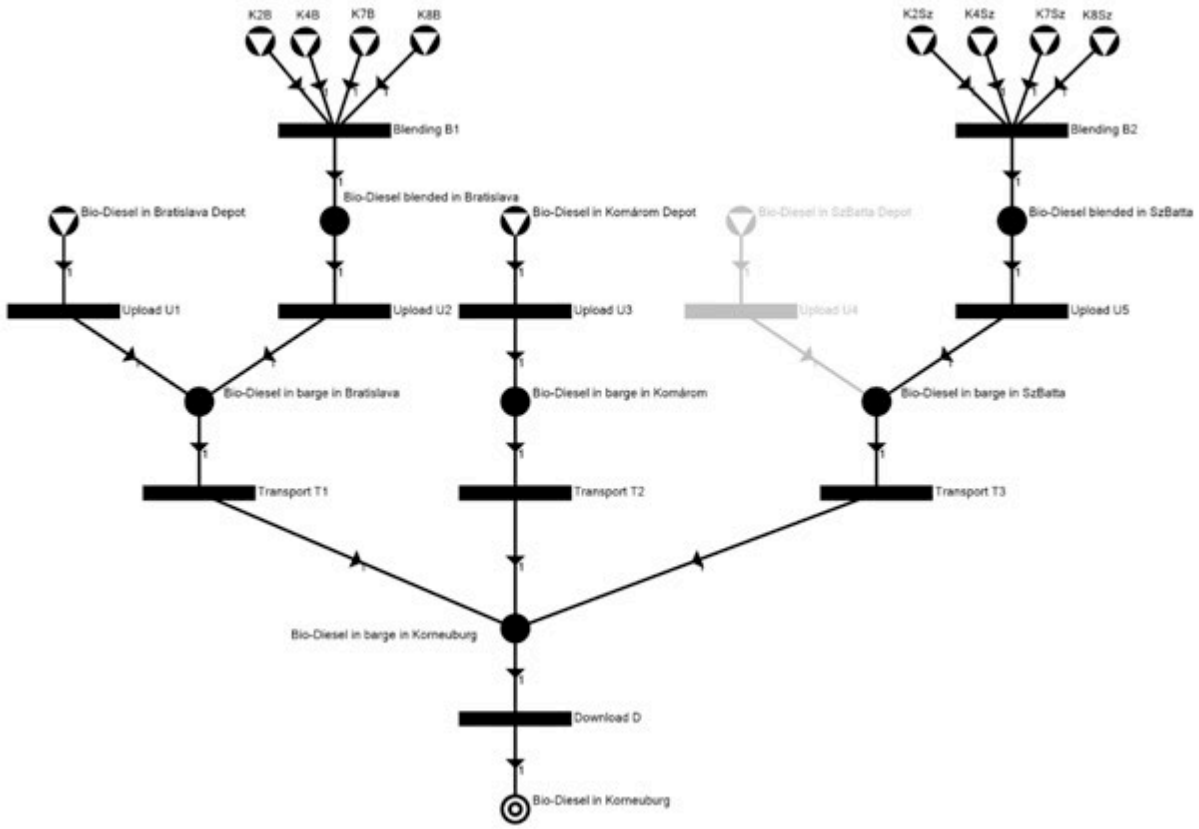

Figure 3: The cost optimal solution of the Bio-Diesel transportation problem

Table 4: The 7-best structures of the case study

Structure	Activities	Cost (€)
#1	B1, B2, U1, U2, U3, U5, T1, T2, T3, D	1.964.320
#2	B2, U1, U3, U4, U5, T1, T2, T3, D	1.973.930
#3	B1, B2, U1, U2, U4, U5, T1, T3, D	2.001.570
#4	B1, B2, U2, U3, U4, U5, T1, T2, T3, D	2.005.970
#5	B2, U1, U4, U5, T1, T3, D	2.016.360
#6	B1, U1, U2, U3, U4, T1, T2, T3, D	2.020.570
#7	U1, U3, U4, T1, T2, T3, D	2.035.370

As we can see, the 'Upload U4' activity does not take part in the cost optimal solution; however, it is different from the profit optimal solution from the cost optimal solution, i.e., when the price is taken into account. Eight feasible solutions exist as the Table 5 shows.

Table 5: Profit and expected profit results based on Algorithm ABB

Structure	Activities	Profit (€)	Expected profit (€)
#1	B1, B2, U1, U2, U3, U4, U5, T1, T2, T3, D	602.773	465.090
#2	B2, U1, U3, U4, U5, T1, T2, T3, D	587.981	466.983
#3	B1, B2, U1, U2, U3, U5, T1, T2, T3, D	556.367	416.902
#4	B1, U1, U2, U3, U4, T1, T2, T3, D	541.341	415.925
#5	B1, B2, U1, U2, U4, U5, T1, T3, D	529.385	419.812
#6	U2, U3, U4, T1, T2, T3, D	511.070	423.136
#7	B1, B2, U2, U3, U4, U5, T1, T2, T3, D	509.512	385.471
#8	B2, U1, U4, U5, T1, T3, D	483.636	413.185

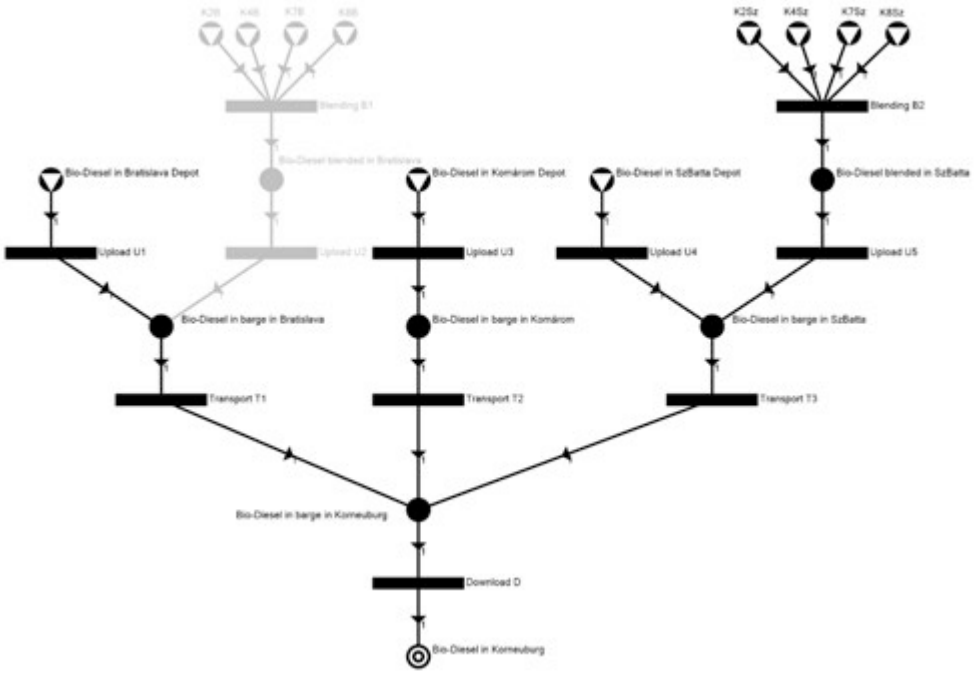

Figure 4: The structure of the optimal solution when the expected profit is the goal function

Figure 4 depicts that optimal structure when the expected profit is optimized. Comparing Table 4, 5 or Figure 2, 3, 4 it can be seen that depending on the objective function the optimal solutions are different. The best structure according to the profit contains all the operating units, while the greatest expected profit can be reached without usage of ‘B1’ and ‘U2’, and the structure without ‘U4’ is the least expensive.

4 Summary

A supply chain problem was introduced in present paper for solving a biodiesel transportation problem using P-graph framework. The mathematical model of the considered task was formalized as a mixed integer linear programming problem. The maximal structure of the transportation network was also given and the optimal solutions for the cost, the profit and the expected profit were calculated with a branch-and-bound algorithm (ABB). The quantity of the transportation and the blending of the biodiesel changes depending on the goal of the optimization. The technique and the results of the optimization of expected profit was also introduced. The results clearly show that the joint investigation of profit, cost and expected profit can only give useful information to the decision makers when there are parameters under uncertainties.

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An Empirical Study on the Perceptions of Audit Benefits: The Case of Serbia

Miroslav Todorović
University of Belgrade, Faculty of Economics, Serbia
todorovic@ekof.bg.ac.rs

Savka Vučković Milutinović
University of Belgrade, Faculty of Economics, Serbia
saska@ekof.bg.ac.rs

Abstract

Since the beginning of the audit, the auditors have had to struggle with many challenges, trying to adapt to the expectations of users of audit reports. The unfulfilled expectations create so-called expectation gap. Although many attempts were made to resolve the expectation gap, the gap is still present and even more stressed during the recent financial crisis. Unlike the countries with a strong auditing tradition, in the former socialist countries auditing does not have deep roots and recognition of benefits of auditing cannot be taken in advance. In this paper, through a questionnaire survey we investigate state of auditing in Serbia, how far the expectations of users of audit reports have evolved and what is the current gap between perceptions of auditors and users. Our findings reveal that there is audit expectation gap regarding auditors' responsibilities, but also regarding auditors' performance.

Keywords: auditing, expectation gap, auditors, financial statement users, Serbia

1 Introduction

It is well-recognized that external audit plays important role in developed economies. By adding credibility to financial statements, auditing reduces information risk for users of financial statements and contributes to better allocation of resources. Nevertheless, the benefits of auditing are sometimes challenged, what is especially true in the cases of big corporate frauds, which were undetected from auditors, or collapses of large companies that previously received unqualified auditor opinion. These cases made it obvious that actual performance of auditing was not in line with expectations of users. However, in other cases the expectations of users exceed that what auditors do or even could do. For the audit profession, the expectation gap is of great concern, because it undermines the public trust in auditing as valuable service. Misunderstandings between users and auditors can lead to "unintended investments, misallocations of resources, unnecessary litigation and/or loss of confidence in the audit function" (Asssare, Wright, 2012). Therefore it is crucial to work on reducing the expectation gap.

Many attempts have already been made to narrow the expectation gap - by the audit profession as well as by lawmakers and regulators. The academic researchers also contributed to these efforts by trying to identify the gap, illuminate its nature and size and suggest some solutions to bridge it. Despite all mobilized efforts the gap is still present and the recent financial crisis makes it even bigger. In the context of this deep crisis, Sikka (2009) emphasizes that "markets do not seem to have been assured by unqualified audit opinion" and explains that existing model of auditing cannot reach users expectations. The discussion of the expectation gap is again provoked and gives impetus for new and up-to-date research on differences between users' and auditors' views of auditors' role and performance.

The expectation gap is not only present in countries where auditing has deep roots, but also and even more in transition countries. The auditing profession in these countries has not been affirmed yet and any misperception of the audit can seriously undermine the efforts to build confidence in assurance that auditors provide. As in developed countries unreasonable expectations on the side of users can be the issue as well as underperformance of auditing, especially given the state of the profession. But unlike the countries with strong auditing tradition, the direction of expectation gap can not be taken in advance. It could be possible that users perceptions of the benefits of auditing are not still developed in the economies with short history of auditing.

Despite the relevance of the expectation gap issue, there has been a lack of scientific studies that have explored this gap in transition economies. To date, such study was not conducted in Serbia. In this paper we present our results of empirical research where we investigate the presence and nature of the expectation gap between auditors and users of auditor's report in Serbia. The study focuses on the perceptions of the auditors and users regarding four important topics: auditors' responsibilities, auditors' performance, benefits of audit and roles that auditors (but also other participants in the financial reporting process) have in deterring and detecting frauds.

This paper is organised as follows. The next section provides the theoretical foundation and a literature review regarding the audit expectation gap. The research questions of this study and research methodology are elaborated in Section 3. A subsequent section presents the study results, followed by analysis and discussion. Finally, the concluding section highlights the most important remarks of the study.

2 Theoretical background and literature review

It can be argued that from the beginning of the modern audit, expectations of users with regards to auditors' duties have been very large and often exceeded what auditors perceived their tasks should be. However, the audit expectation gap was first defined in audit literature in 1974 by Liggio (1974). He described this gap as the "difference between the expected performance perceived by auditors and users". Ever since this issue have attracted a lot of attention. In 1978 the Cohen Commission issued report with evidences that audit expectation gap existed in USA and gave some recommendations for narrowing the gap. According to the Commission, the gap related to the difference between "what the public expects or needs and what auditors can and should reasonably expect to accomplish" (AICPA, 1978).

The broader definition of expectation gap was introduced by Porter (1993), who states that the gap lies between "society's expectations of auditors and society's perceptions of auditors' performance". She identified that unfulfilled expectations of users could be attributable to

unreasonable expectations of users, deficient auditing standards and poor auditors performance. According to her empirical study conducted in New Zealand, 34% of the expectation gap was due to unreasonable public expectation. Deficient standards contributed 50% and sub-standard performance of auditors additional 16% to the formation of the expectation gap.

Numerous empirical studies (Humphrey *et al.,* 1993, Siddiqui *et al.,* 2009 etc.) were conducted in order to identify whether an audit expectation gap exists and if exists, what are the key factors that cause the gap and how to bridge the gap. Most of these studies revealed that expectation gap existed. The recent UK study conducted by Porter (2012) shows some interesting findings. Between 1999 and 2008, the expectation-performance gap was reduced in UK and even each component of the gap was also reduced. The unreasonable expectations were reduced mainly thanks to the widespread public discussion of the relevant auditing issues. Changes to auditing standards resulted in a narrowing of the deficient standards gap and more stringent monitoring of auditors' performance contributed to low level of deficient performance gaps. In the same period in New Zealand, the reasonableness gap and deficient performance gaps widened.

The research studies were also conducted in some countries with short history of external auditing. Interestingly, in these countries the audit expectation gap was already present. It supports the assertion that audit expectation gap is unavoidable linked with auditing services. In Bangladesh, Siddiqui *et al.* (2009) found the most significant gap between auditors and users in the area of auditors' responsibilities, although some gap was identified in other area too (audit reliability, decision usefulness etc.). They also tested effects of education on reducing the gap and found the positive impact. Jun Lin and Cheng (2004) confirmed the expectation gap in China with respect to audit objectives, auditors' obligation to detect and report frauds and third-party liabilities of auditors. Their study proved that the benefits of audit are highly recognised in the changing business environment in China. The results of the studies in Malaysia uncovered the wide gap in this country (Fadzly and Ahmad 2004, Lee *at al*. 2007). Many of the studies used the same methodology (Porter's framework or questionnaire developed by Schelluch, 1996), what enable performance of cross-country comparative analysis.

Finding the ways to reduce the expectation gap is the most important issue, whenever such gap is identified. A lot of actions and proposals have been made and they can be generally summarised in two groups: those that contribute to mitigation of unreasonable expectation of users and those that are directed to improvement of quality and relevance of the audit. In cases of severe external shocks and a very wide expectation gap, all interested parties must be included in resolving it; not only accounting profession, but also law makers, regulatory bodies, academics, and public representatives (Todorović, Vučković Milutinović, 2014).

Although many efforts have been made to eliminate the gap, it is still present. Education of the public and improving the content and "wording" of auditor's report are the most used measures for reducing unreasonable expectations and they can have positive effects (Schelluch 1996, Siddiqui at al. 2004). Nevertheless, their scope seems limited. Many research have shown that unreasonable expectations survive in some extent. Recent study of Asare and Wright (2012) show that there are significant gap in understanding basic objectives and limitation of the audit. The users still have a higher level of confidence than auditors that the standard audit report communicates message that the company is well managed, represent

sound investment or meet its strategic goals. Gold, Gronewold and Pott (2012) in their study of changes of ISA 700 did not prove that longer form of audit report reduced expectation gap.

It can be observed that the expectations of public are hard to reduce and there are number of those who advocate the extending of the role of auditors. The Association of Chartered Certified Accountants (ACCA, 2011) expresses the need for development of audit which would "focus on business risks rather than just the risks of material misstatement of the financial statements" which will help to address "the so-called 'expectations gap', rather than continuing the long-standing, and futile attempts to 'educate' the public into the limitations of audit." Some expectations of users that exceeded duties of auditors have been recognised as important to be achieved by auditors, and consequently has been included in new and revised auditing standards (for instance, more rigorous requirements with regards to frauds). The latest changes in international auditing standards related to audit report are also intended to meet some unfulfilled needs of users. The auditor's report will be more informative for users, particularly as a result of introducing in report the discussion of "key audit matters".

Many critiques are expressed due to low quality of auditing. Among other reasons that cause poor auditors' performance, Sikka *et al.* (2009) quote the profit orientation of auditing firms and restricted liability to third parties, and conclude that "the current auditing model is flawed and cannot be repaired". In practice, the responses to the substandard performance of auditors usually consist of: strengthening the independence rules, improving quality control standards in audit firms, establishing more comprehensive monitoring of auditors' performance and implementing more rigorous sanctioning regime.

Serbia has its specificities with regards to audit development. During the period of socialism, a system of state control over financial reporting was established. Precisely, authorised state institution performed so-called "economic and financial auditing". In some of its elements, this kind of auditing was similar to the modern external auditing. However, due to the transition to the market economy many reforms took place, and this system of auditing was abolished. The model of auditing from capitalist economies was adopted already in the first half of the 1990s. Since 2003, mandatory auditing of financial statements was required to be performed in conformity with International Auditing Standards (Law on Accounting and Auditing, 2002). It was prescribed for large and medium-sized legal entities, as well as the issuers selling their long-term securities by public offering. These provisions were not in compliance with the state of the profession and the real needs for auditing services, what perhaps led to some performance gap immediately and negative attitude towards benefits of auditing.

According to the World Bank Report (2005) the stage of development of the audit profession did not justify such broad scope of statutory audit; in 2004 160 certified auditors working in 32 registered audit firms should audit approximately 3,200 entities. This report identified a broad scope of other problems, such as lack of adequate public monitoring over auditing profession, lack of some system to ensure that auditors comply with the IFAC Code of Ethics for Professional Accountants, lack of mechanisms to protect auditors' independence (a statutory auditor could resign or be dismissed to avoid an qualified opinion) etc. In 2013 new Auditing Law with some improvements was enacted.

3 Overview of research methodology

In order to obtain understanding of important auditing issues in Serbian environment, we conducted an empirical study. Through examination of the perceptions of key participants on auditing market – auditors and users, we tried to reveal the current state of the audit practice in Serbia. The goal of the study was also to identify possible expectations gap between auditors and users.

The expectation gap related to auditors' responsibilities was proved by many previous studies in different countries. As a rule, the users expected auditors to have greater responsibilities than auditors themselves perceived their responsibilities were. This may not be the case in Serbia. In Serbia due to short history of independent external auditing, the expectations of the public could still not be developed. Given that auditing was not actually market-driven but imposed by law, it is possible that it has been seen as just one more bureaucratic burden for companies without much sense. On the other hand, it is possible that in business environment characterised with low quality of financial reporting and a significant number of companies' bankruptcies, users see auditing as panacea; they expect that auditors can enhance the quality of financial statements, but also detect all frauds or be in charge of soundness of internal control structure. This would mean that expectations of users are higher than those of auditors. Therefore, our first research question addresses the perceptions of auditors and users with regards to auditors' responsibilities: *Does the expectation gap related to auditors' responsibilities exist between auditors and users in Serbia?*

Although there is no precise criteria for a number of CPA practitioners or CPA firms in relation to a number of companies that should be audited, it is obvious that these two numbers must be commensurate if the auditing is expected to be well performed. According to Chamber of Certified Auditors of Serbia, there are currently 60 registered audit firms and 241 licensed certified auditors (for comparison, in Croatia there are 234 firms and 514 auditors). Total number of companies required to have audited financial statements is cca. 4,700 (Opinion on Draft Law on Auditing, 2013). It could be concluded that the situation is still unsatisfactory as it was in 2004 (World Bank Report, 2005). The audit profession's capacity is not sufficient, so this can result in sub-standard performance of auditing services. Some other specifics of Serbian environment can be also recognized as those that contribute to underperformance of auditing. Until new Law on Auditing (2013) the public oversight of auditing profession has not been established nor any kind of external quality control of the work of audit firms was prescribed. Sanctioning regime was not functioning. Although new Law on Auditing filled these "holes", it will probably take time to see real improvements in the practice. In these circumstances, it is reasonable to assume that users are dissatisfied with auditors' performance. Because auditors could be more optimistic and biased in assessing their own performance, to examine this issue we posit research question: *Does expectation gap regarding auditors' performance exist in Serbia?*

If users perceive performance of auditing in Serbia as poor it can result in their low perceptions of the merits of auditing. It could be also observed that in recent financial crisis considerable number of companies in Serbia collapsed and some of them previously received unqualified opinion on their financial statements or qualified but with relatively mild qualification, which could raise doubt about benefits of audit and users' reliance on auditor reports. On the other hand, the quality of financial reporting in Serbia is very questionable. According to the Law on Accounting (2013), there are no qualification requirements for those who maintain books and prepare financial statements. Although the Law prescribes that financial statements must be prepared in accordance with IFRS, the level of expertise of those who are in charge for financial reporting is not formally verified and may be seen as

questionable. In such circumstances it could be expected that users of financial statements recognise the benefits of auditing as huge. We explored the perceptions of users towards benefits of auditing through their attitude to usefulness of audit report and to proposal for narrowing or extending the scope of the mandatory audit. We also explored attitudes of auditors. Our next research question is specified as: *In what extent the benefits of audit are recognised by auditors and users in Serbia?*

It seems that the full consensus about the role of auditors in detecting frauds has not been reached. After large corporate scandals, such as Wordcom, Enron, Parmalat etc., the public disappointment with the auditing profession in regard to undetected frauds had culminated. A lot of actions were undertaken worldwide, although the most radical reform was introduced in USA with Sarbanes-Oxley Act. To date, there is lack of the studies of the financial reporting frauds in Serbia, so we want to investigate perceptions of users and auditors in relation to possibilities of prevention/detection of frauds.

In accordance with the law, joint stock companies and limited liability companies in Serbia can have one-tier or two-tier model of board i.e. corporate governance. In the case of one-tier model, if the number of directors is three or more, they form a board of directors. In the case of two-tier governance, if the number of executive directors is three or more, they form the executive (management) board. A company with the two-tier model has to have a supervisory board. The choice of model is left to the company i.e. its owners.

The law enforces internal audit (called: internal monitoring) for joint stock companies, and public joint stock companies must have at least one person who is a certified internal auditor. The head of the internal audit reports to the audit committee. If the non-public joint stock company does not have audit committee then reporting is directed towards the board of directors or the supervisory board. Limited liability companies are free to decide whether to establish an internal audit or not.

We were interested to see which party (management, board of directors including supervisory board in case of two-tier model, internal auditors or auditors) is seen as the most powerful and most trustable party to deter or/and detect frauds and accordingly we put the last research questions as: *What are the perceptions of users and auditors with regards to the role of auditors and other key participants in financial reporting in deterring of and detecting frauds?*

The research was conducted by collecting responses through the survey with auditors and users of financials statements in the period 12.12.2014 to 15.01.2015. Responses were collected using a web-based Google Forms survey tool in Google Drive.

We used the purposive sampling technique (judgment sampling) deliberately choosing respondents - on the auditors' side dominantly form population of employees of the Big 4 audit firms that have operations in Serbia (18.2% of the respondents were not from the Big 4), and on the users' side from the population of bank's officers dominantly of foreign banks that have subsidiaries in Serbia. While the choice on auditors' side sounds reasonable by itself, the choice of users requires a brief explanation. Namely, Serbian financial market is rather underdeveloped and financial system is bank-centred. Although there are a number of institutional investors and individual investors their role in companies' financing is immeasurably weaker in relation to the role of banks. In these circumstances it was easy to identify bank's officers as main users of financial statements in our study. In addition to officers who primarily work with the loan approval, monitoring and collection of loans, in our study also participated analyst of financial statements working in leasing subsidiaries or departments of banks.

The questionnaire contained questions about the name of the company but the respondents were made clear that those data would not be publicized. Further, the respondents were asked about their job title and their experience (in number of years). On the auditors' side we collected the answers from practitioners starting from the position of assistant to the position of manager. In order to increase the representativeness of the results we did not take into account the responses of employees with less than one year of experience. Largest number of users worked as credit officers, risk analysts, credit analysts, credit risk managers or on job positions with similar names, including the heads of these departments (head of risk department, head of corporate banking sector etc.). The total number of respondents was 71 of which there were 33 auditors and 38 bankers. Out of total, 32 respondents had less than five years of experience and 39 more than five years of work experience, of which 12 with more than ten years of experience.

Perceptions of respondents were examined using mainly a seven-point Likert Scale (1 - strongly disagree, 7-stronly agree), where we, in order to avoid central tendency bias, asked respondents not to follow the rule of giving neutral ("middle") option, not to give "socially desirable" and "right" answers, since they do not exist. Respondents had to provide answers to all questions, because it was technically impossible to return an incomplete questionnaire.

We run t-tests to compare two sample means of auditors and users to determine if there is any significant difference between their perceptions. When selecting a t-test for the analysis of the results, we were guided by the conclusion of DeWinter & Dodo (2010) that t-test can be used instead of the Mann-Whitney-Wilcoxon test since the two tests had equivalent power.

4 Results and analysis

The results of the study are presented in four sections. Each section relates to one of previously determined research questions. Most of results are given in form of tables. Each table presents a set of statements used in questionnaire to examine related research question. The percentages of auditors and bankers who agreed or disagreed with survey statements are shown in these tables. To calculate the percentages, we determine the respondents that chose 1, 2 or 3 on the opinion scale as those who "disagree" and the respondents that chose 5, 6 or 7 on the opinion scale as those who "agree". The tables also contain descriptive statistics, precisely group means and p-value. The significant levels are explicitly indicated as: *significant at the level 0,10 level, ** significant at the level 0,05 level and *** significant at the level 0,01 level.

4.1 Auditors' responsibility

Table 1 presents results for the statements related to auditors' responsibility. Significant gap was identified between auditors and bankers in 4 from 5 statements. Regarding auditor's responsibility to detect all frauds, the auditors and bankers had significantly different opinions. The majority of auditors (69.70%) disagreed with this statements, with group mean of 2.455. However, a level of disagreement was lower for the bankers (34.21%), with a group mean of 4.237 (significant at the 0.001 level). The gap is also identified regarding auditor's responsibility to maintain accounting records. The auditors strongly disagreed with this statement (mean of 1.727), but although a significant part of the bankers also disagreed (64.42%) it is interesting that more than a quarter of the bankers (28.95%) expected auditors to maintain clients' records, what definitely indicate presence of unreasonable expectations.

The views of the two groups of respondents also differed at a statistically significant level over the third statement that auditor is responsible "for soundness of internal control structure". As in the previous statement, the results reveal strong disagreement on the part of the auditors and a rather lower disagreement on the part of the bankers. Again, due to unreasonable expectations more than a quarter of the bankers (28,95%) held auditors responsible on this issue.

Does the expectation gap related to auditors' responsibilities exist between auditors and users in Serbia?	%				Mean		
	Auditors (n=33)		*Users (n=38)*		*Auditors*	*Users*	*p-value*
	Disagree	*Agree*	*Disagree*	*Agree*			
The auditor is responsible for detecting all frauds	69.70	12.12	34.21	55.26	2.455	4,237	0,000***
The auditor is responsible for maintaining accounting records	87.88	9.09	64.42	28.95	1.727	3.000	0,005***
The auditor is responsible for soundness of internal control structure of the entity	81.82	12.12	52.63	28.95	2.303	3.368	0,036**
The auditor is responsible for disclosing in the audit report all uncovered frauds, inefficiencies and irregularities	33.33	57.58	7.89	84.21	4.515	6.237	0,000***
The auditor is responsible for preventing frauds	72.73	12.12	63.16	10.53	2.303	2.477	0,714

Table 1: [Perception of auditors' responsibility]

In addition, a significant difference in mean scores between auditors and bankers was found concerning auditor's responsibility to disclose "all uncovered frauds, inefficiencies and irregularities". The expectations of the bankers are high with regards to this auditor's responsibility. Their group mean is 6.237 (what is the highest mean value revealed through this study). More than 4/5 bankers agreed with this statement of responsibility. Surprisingly, the majority of auditor respondents (57.58%) also agreed with this responsibility, but 33.33% disagreed (group mean of 4.515). It is worth mentioning that the recent discussions and changes in auditing standards, precisely requirement for auditors to communicate "key audit matters" in their report, were reaction to obvious needs and expectations of users to get more informative audit report. In that context, we can interpret rather high group mean for auditors. It can be said that one part of unreasonable expectations of users have now become reasonable thanks to improved and extended auditor report. For the last question in this section regarding auditor's responsibility, both groups of respondents disagreed with no statistically significant difference that "auditor is responsible for preventing frauds" (bankers' second lowest mean in survey 2.477).

4.2 Auditors' performance

Table 2 presents results for the statements regarding auditors' performance. Only 23,68% of the bankers expressed agreement with the statement that "the CPA firms in Serbia are capable to perform their audit work properly", where "capable" was defined as having enough audit staff, expertise and time to perform the audit work. Their group mean was 3.474. Although the auditors were a bit more positive (group mean of 3.667), they also in great percentage disagree with this statement. No statistically significant difference appeared between the respondents groups. The results support our hypothesis that the current state of the audit profession in Serbia is not satisfactory.

Does expectation gap regarding auditors' performance exist in Serbia?	%				Mean		
	Auditors (n=33)		*Users (n=38)*		*Auditors*	*Users*	*p-value*
	Disagree	*Agree*	*Disagree*	*Agree*			
The CPA firms in Serbia are capable to perform their audit work properly	45.45	36.36	47.37	23.68	3,667	3,474	0,639
Auditors in Serbia make enough efforts to perform their audit work properly	24.24	66.67	36.84	28.95	5,000	3,684	0,000***
Auditors in Serbia obtain sufficient evidences in order to form their opinion	15.15	72.73	34.21	31.58	5,303	3,789	0,000***
The auditors often fail to modify their opinion	27.27	45.45	23.68	55.26	4,454	4,711	0,529

Table 2: [Auditors' performance]

In contrast to the previous statement where the responses of the auditors and bankers were close, the next statement revealed significantly different viewpoints of these two groups of respondents. The majority of auditors (66,67%) agreed that auditors "make enough efforts to perform their audit work properly" while less than 1/3 of the bankers had the same perception. The group mean of the bankers was substantially lower than that of the auditors (3.684 vs. 5.000, significant at the 0,001 level). It could be interpreted that the bankers perceived auditors' performance as somewhat questionable. The data also indicate that there are challenges for auditors in Serbia to improve their performance.

The reactions to the following statement in our survey further supported the presence of the performance gap. The auditors mainly agreed (72,73%) that they "obtain sufficient evidences in order to form their opinion." The bankers were more sceptical about the sufficiency of the audit evidences. The group means were 5,303 and 3,789 for auditors and bankers, respectively (significant at the 0.001 level).

The responses of the both groups of respondents were fairly consistent (the gap does not exist) regarding the notion that in accordance with business environment in Serbia auditors should more frequently issue modified opinion instead of standard opinion. The significant part of the both of the groups (45.45% of auditors, 55,26% of users) supported this view, what clearly indicate that the auditors were also aware of this deficiency.

4.3 Benefits of audit

Unfortunately, users assessed the statement that "an unqualified auditor's opinion means that the financial statements are reliable" with statistically significantly lower grade than that of the auditors (4.079 vs. 4.667, see Table 3). Although over 60% of the auditors agreed that financial statement with their unqualified opinion should be viewed with confidence, almost 30% of users did not agree with this position. It is obvious that users did not perceive unqualified opinion sufficiently useful for making business decisions.

Both groups of respondents agreed with the observation that the financial reports of companies that have modified opinion should be viewed with scepticism. This statement is assessed with quite high marks (5.424 - auditors, 5.447 - users) and gap in perceptions is not registered. Comparing these results with those related to previous statement, it is obvious that users believe more in modified than in an unqualified audit opinion.

In what extent the benefits of audit are recognised by auditors and users in Serbia?	%				Mean		
	Auditors (n=33)		*Users (n=38)*		*Auditors*	*Users*	*p-value*
	Disagree	*Agree*	*Disagree*	*Agree*			
An unqualified auditor's opinion means that the financial statements are reliable	15.15	60.61	28.95	44.74	4,667	4,079	0,088*
Financial statements of companies that have modified opinion should be viewed with scepticism	12.12	75.76	7.89	78.68	5,424	5,447	0,948
Medium-sized companies should be exempt from the mandatory audit	81.82	6.06	84.21	10.53	1,879	1,921	0,916
Audit should be mandatory for all companies	48.48	42.42	52.63	42.11	3,727	3,737	0,987

Table 3: [Benefits of audit]

Despite not so high opinion on the capacity of a CPA firm, the gap in perception related to efforts and evidence, and not so high confidence in the unqualified auditors' opinion, bankers had a very unfavourable position regarding the potential abolition of the mandatory audit for medium sized companies (even 84.12% of bankers were against it, with a group mean of only 1.921). This idea was also very unfavourable assessed by the auditor (81.82% against, group mean of only 1.879). Based on these data, we could conclude that the both groups recognized the benefits of audit. It could be also argued that the bankers have very rational thinking – citing the auditor's report can be a sort of justification or absolution for the bad decisions they have made, but also, any audit that does not cost us, is better than nothing. Such a "free lunch" seems especially attractive for bankers in the segment of medium-sized companies, since unlike large enterprises such companies have more pronounced problem of unsatisfactory financial reporting and information asymmetry. What's more, even 42.11% of the bankers supported the idea of prescribing mandatory audits for all companies. Almost the same percentage of the auditors was committed to this proposal. The percentage of auditors who support this option is not negligible indicating that a good part of the auditors have irrational faith that extension of mandatory audits to all companies is meaningfulness.

4.4 Fraud Deterrence/Detection

As we presented in the first section, there are very low expectations of both users and auditors in terms of auditors' liability for preventing frauds. However, differences in terms of what these two groups of respondents think about who should be responsible in deterring fraud do exist.

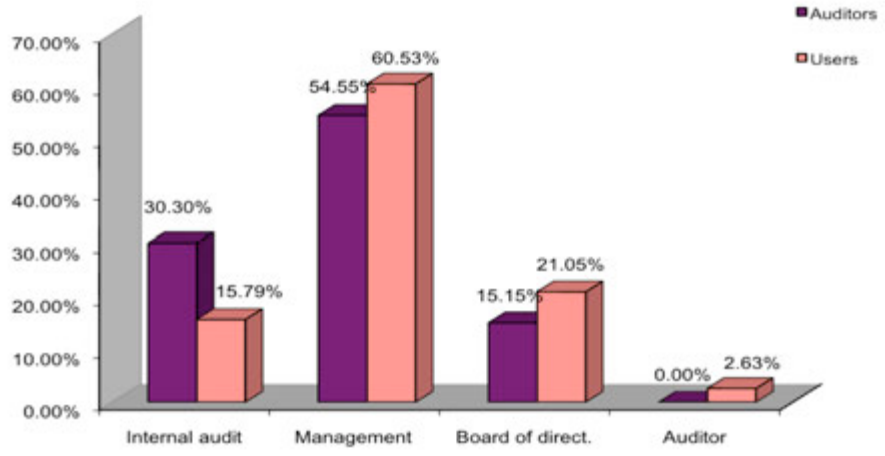

Chart 1: [Primary responsibility for deterring fraud]

As shown in the Chart 1, by far the largest proportion of both groups of respondents believed that the company's management should have primary responsibility for the fraud deterrence. However, in second place the auditors saw internal auditors in the companies (30.30% of the auditors), while the bankers believed that it should be the board of directors (21,05% of the bankers). Relatively insignificant percentage of the bankers saw external auditors as the most responsible.

On the side of fraud detection both groups saw the role of auditors as relatively important (see Chart 2). However, the views of the two groups differed significantly, with respect to the participant in the financial reporting process who is most responsible for detecting fraud. While the auditors had relatively balanced attitude, having the highest expectations of internal audit and moderate of the board of directors, auditors and management, the bankers expressed huge expectations of internal audit (71.05%), while they did not expect anything from boards of directors (0%).

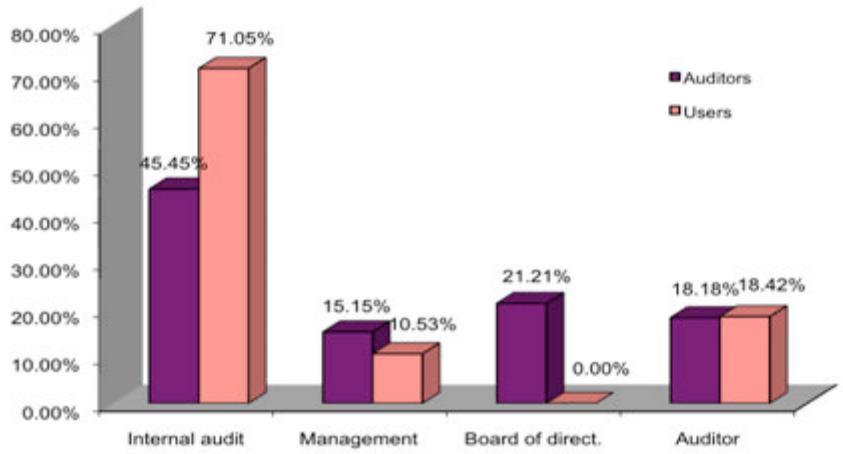

Chart 2: [Primary responsibility for fraud detection]

This difference in points of view could be potentially explained by the fact that the auditors, although aware of the importance of internal audit, were also more aware of the limitations of internal audit. The only potential explanation for the lack of expectations of bankers in relation to the board of directors is that bankers are otherwise disappointed with the role and effectiveness of the board of directors in the Serbian corporate governance practice. Significantly lower assessment of the reliability of the board by the bankers we also found asking respondents the question of how reliable and trustworthy they see mentioned players in deterring/detecting fraud, as shown in the Table 4. Only 13.16% of the surveyed bankers assessed the board of directors as reliable in deterring/detecting fraud.

Who is reliable and trustworthy in deterring of and detecting frauds?	*%*				*Mean*		
	Auditors (n=33)		*Users (n=38)*		*Auditors*	*Users*	*p-value*
	Disagree	*Agree*	*Disagree*	*Agree*			
Management	87.88	6.06	71.05	13.16	2,364	2,789	0,177
Board of directors	48.48	27.27	63.16	13.16	3,667	3,026	0,052*
Internal audit	21.21	60.61	26.32	47.37	4,606	4,477	0,715
Auditors (external)	18.18	54.55	21.05	44.74	4,758	4,500	0,468

Table 4: [Deterring/detection of fraud]

Unfortunately, both groups of respondents gave very low ratings (2.364 and 2.789) to managers as a potentially reliable mechanism for deterring/detecting fraud. Only 6.06% and 13.16% of the auditors and the bankers, respectively, believed that managers could be trusted in this role. Finally, overall assessment of the reliability of all the potential participants by both groups is relatively weak (marks from 2.364 to max. 4.758). However, both groups perceived external auditors as the most reliable in deterring/detecting fraud. Slightly lower marks both groups gave for internal auditors.

5 Conclusion

Our findings reveal that there is audit expectation gap in Serbia regarding auditor's responsibilities. The users of audit reports in Serbia have somewhat unrealistic expectations regarding the responsibilities of auditors to detect all frauds, and the responsibility for keeping accounting records and soundness of the internal control in companies where they performed the audit. Activities to educate users about existing responsibilities of auditors are needed, particularly bearing in mind that bankers can be generally seen as sophisticated users while other users maybe have even less knowledge about what auditing really means. It is hoped that the results of this study will motivate the Serbian audit profession to engage itself more in clarifying what exactly the responsibilities of an auditor are. It is also hoped that audit profession will take steps in order to improve its performance – our study clearly indicate that auditors and users agree that the capacity of audit firms in Serbia is relatively weak. However, users have a much lower opinion of how auditors invest effort in conducting an audit and collecting audit evidence.

Auditors and bankers agree that the current scope of mandatory audit should not be changed. There is a great aversion regarding the narrowing the scope in a way that medium-sized companies will no longer be subject to mandatory audit. While both groups agree in their assessment that the financial statements with a modified opinion should be viewed with scepticism, significantly fewer users believe that the financial statements with the unqualified opinions can be viewed with confidence. Not only users, but also the auditors believe that in many cases the auditor's opinion may contain more stringent qualification than the one was given or modified opinion instead of unqualified opinion. Finally, auditors and users believe that management should be responsible for deterring fraud, but unfortunately, both groups of respondents do not believe that managers in Serbia could potentially be a reliable mechanism for deterring/detecting frauds. Two groups differ significantly in terms of the most powerful force to detect frauds - while auditors have relatively balanced attitude bankers have huge expectations of internal audit, and do not expect anything from the board of directors. Both groups perceived external auditors as the most reliable force in deterring and detecting fraud.

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New Insights in Business Cycle Coherence; Empirical Evidence from Slovenia1

Daniel Tomić
Juraj Dobrila University of Pula
Faculty of Economics and Tourism »Dr. Mijo Mirković«, Pula, Croatia
dtomic@unipu.hr

Marija Kenjereš
Juraj Dobrila University of Pula
Faculty of Economics and Tourism »Dr. Mijo Mirković«, Pula, Croatia
markenje@unipu.hr

Abstract

Many argue that business cycle analysis has served as an important impulse in stimulating and provoking interesting academic and professional debates, especially within the European Union. Measuring business cycles is critical in determining the stylised facts of the business cycle regarding aggregate macroeconomic behaviour over time. Although a cycle in economic activity is a stylized fact, in macroeconomics it is less clear as to when the economic growth dynamic coincides between countries/regions and when these dynamics synchronise and/or converge. The aim of this paper is to look into business cycle aspects of the Slovenian economy vis á vis European Union in terms of coherence measures. By applying methodology proposed by Mink, Jacobs and de Haan we calculated two measures of coherence, namely synchronicity and similarity in order to capture both co-movement and amplitude of the Slovenian growth perspective presented as the output gap variable. Output gap calculations are based on the growth cycle approach for deviation cycle variable is to be derived using the HP filter. In addition, some mediating macroeconomic variables are also being included in the analysis in order to provide us some new insights regarding business cycle coherence in the optimal currency area of which Slovenia has become an indispensable part.

Keywords: business cycle, synchronicity, similarity, HP-filter, Slovenia, European Union

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1 Introduction

The main goal of this paper is to evaluate business cycle movements and coherence concepts within the Slovenian economic perspective. Many argue that business cycle analysis has served as an important impulse in stimulating and provoking interesting academic and professional debates, especially within the European Union (EU). Measuring business cycles is critical in determining the stylised facts of the business cycle regarding aggregate macroeconomic behaviour over time. Complexities of macroeconomic relations in Slovenia reveal structural problems that dwell upon both fiscal and monetary policies. Therefore, by analyzing business cycle aspects of the Slovenian economy we are in fact addressing key macroeconomic issues that are or might be crucial for economic stability and sustainable progress. Considering different roles of fiscal and monetary policies within decision-making dilemma, each economic problem should be approached differently depending upon the specific cycle characteristics of the country. Our paper is supplement to the strand of literature that tries to evaluate controversies over economic policies in Slovenia i.e. their compatibility and/or coordination as well as it offers constructive analytical commentary.

If we ought to observe the business cycle coherence concept we should start from the macro aspects. Many growth motivated studies since the 1960s have shown that cyclical regularities and fluctuations can explain real economic movements, therefore studying business cycle has become an indispensable part of growth related research. The term synchronization, which is built on the coherence dynamics, is nothing but an attempt to clarify the interdependence between individual sectors, countries or regions. It is now well established truth and fully known fact that the world is governed by the globalization process. Therein the key in explaining the global financial crisis could be sought in globally synchronised behaviour. This could be the basis, for easiest way to clarify the very concept of synchronization, and so the synchronization of business cycles. Empirical evidence suggests that synchronization of business cycles across countries helps in determining the desirability for a common currency. The decisive period for Slovenia was the period of implementation of reforms from 1991 to 1994. Though Slovenia, before entering the EU and ERM2, tolerated high inflation rate, it succeeded in setting the goals that were pointed towards the European tradition which helped in turning the position from recession to growth. By analyzing disproportion in lags/leads behaviour of the Slovenian real macroeconomic variables together with the coherence approach we want to reconcile with vast empirical evidence supporting the hypothesis that European integration process leads to greater business cycle convergence and synchronisation which finally leads to greater economic welfare in each of the member country.

In order to provide some stylized facts on the macroeconomic behaviour of selected variables we opted for deviation cycle analysis. Output gap calculation are based on the growth cycle approach for deviation cycle variable is to be derived using the HP filter. By applying methodology proposed by Mink et al. (2012) we calculated two measures of coherence, namely synchronicity and similarity in order to capture both co-movement and relative amplitude of the Slovenian growth perspective presented as the output gap variable. Quarterly data were collected from International Financial Statistics and Eurostat ranging from 1992Q1 to 2014Q2 in regards to different aspects of the analysis.

2 Theoretical background and main empirical facts

Before we get any further into the topic let us clarify some basic terminology. Broadly used term business cycle synchronization, as an indicator of the degree of co-movements of the fluctuations across countries and time, is a mere coherence measure. Hence, most of the scholars use term synchronisation to explain coherence between the cyclical patterns of growth between the countries. We will follow their example in this theoretical part, though in the empirical section we will make a distinction, namely methodological, distinguishing two coherence measures (see *Section 3*). For now, synchronisation appellation will be sufficient.

The business cycle synchronization process is observed over a period of time, but also refers to the totality of mechanisms; from time perspective, definition of co-movements to the ways of recovery. Generally, synchronization of business cycles can be seen as a positive result of external influences in some countries, but also as a problem that occurs in response to external shocks. Furthermore, the notion of synchronization is frequently related to the question of optimum currency areas, as it has come to be recognized as a prerequisite for any higher level of economic integration such as European Monetary Union (EMU) for example. As Camacho et al. (2006) point: 'When countries join a monetary union they leave to supranational decision maker traditional instruments for the control of the business cycles. Obviously, the optimality of this delegation of the decisions to a higher authority will be a direct function of the similarities across these economies. If the economies move together, we might think that they need the same type of economic policy decisions at the same time. If, there is no synchronization of their business cycle co-movements, we might think that different solutions are optimal for different economies and probably, the costs associated to an economic union might be higher than the gains'. Important question for the EU as well as Slovenia is whether economies move according to some common driving forces.

In accordance to the arguments of Kenen from 1969 on the point of factor mobility, the literature on business cycle synchronization has also highlighted the importance of sectoral similarity (e.g. Imbs (2006), Clark and van Wincoop (2001), de Haan et al. (2008)). Countries with similar economic structures are more likely to be affected by similar demand shocks, while countries with dissimilar structures will experience a different timing of demand shocks. Sectoral dissimilarity between countries is supposed to result in different business cycles. As found in Siedschlag and Tondl (2011), specialization has also an indirect positive effect *via* trade.

Existing literature on the issue of cycle synchronicity is vast, especially one dealing with the EU and the EMU. Camacho et al. (2006) with three different measures of synchronisation found relatively high linkages across euro countries, but these are prior to the establishment of the monetary union. Monsour (2003) found that world component is generally more important than the European component; European component varies widely among EU members. Van Aarle et al. (2008) came to overall conclusion that on average business cycle convergence in the euro area has not changed substantially since the introduction of the euro. Walti (2009) by using probit regressions of synchronicity found that although the introduction of the euro has raised the likelihood of business cycle synchronicity, it has not affected the relative amplitude of business cycles. Antonakakis and Tondl (2011) reassessed that business cycles have become more synchronised in the EU. Mink et al. (2012) concluded that the synchronicity and similarity between output gaps of individual countries and the reference fluctuate over time, and often are not higher than would be expected under output gap independence.

Though we can find numerous studies on this topic, Slovenia was not so often included in them. Yet we found few interesting studies that included Slovenia and their conclusions are conceptually related to ours. Majority of studies suggested significant correlation between business cycles of EU and Slovenia. Traistaru (2004), Jagrič and Ovin (2004), Fidrmuc and Korhonen (2006), Savva et al. (2007), Levasseur (2008), Afonso and Sequeira (2010), Siedschlag (2010), Stanisic (2013) and etc. found that Slovenia, together with Poland and Hungary had one of the highest average correlations of business cycles with the euro area. This is probably due to their geographical proximity, economic smallness and historical factors that influenced their trade patterns, as stated by Stanisic (2013). Afonso and Sequeira (2010) also noticed very high degree of business cycle synchronization to that of some EU-15 countries. Jazbec (2013) inclined that synchronization of Slovenian business cycle with the euro area and the main trading partners was increasing and was at its peak around the entry in the EU and the Euro adoption, hence the increase was driven by implicit trade integration. He also concluded that recent de-synchronization termed as decoupling is not due to trade decrease but that the most likely reasons could be found in volatile domestic financial factors.

3 Methodology and data

Methodological framework of this study is based on two approaches or better to say analysis: (1) evaluation of cyclical characteristics of main macroeconomic variables and (2) measurement of business cycle synchronisation of the Slovenian economy within the EU. Both approaches are relevant in explaining the business cycle dynamics since we know that short-run disturbances can produce extremely negative effects on one economy, therefore it is of utmost importance to scrutinize how business cycle *de facto* evolves over time

First, in order to evaluate cyclical components of selected macroeconomic variables we followed the works of Stock and Watson (1998), Agresti and Mojon (2001), and Napoletano, Roventini and Sapio (2005).). Though their work was based on Baxter-King filter, we used Hodrick-Prescott (HP) filter that has come to be recognised as standard method for removing long run movements from the time series in the business cycle literature. Furthermore, we tested integration properties of the data to evaluate their methodological possibilities (similary to Benazić and Tomić, 2014). The popularity of the HP filter to detrend a time series is certainly due to the fact that it is easy to estimate and to comprehend. Hodrick and Prescott's (1997) analysis was based on the assumption that time series are consisted of cyclical and growth components, so if growth accounting can provide estimates of growth components with errors that are small relative to the cyclical component, computing the cyclical component is just a matter of calculating the difference between the observed value and the growth component. It resulted in creation of the filter that became standard method for removing long run movements from the time series in the business cycle literature. The HP filter focuses at removing a smooth trend τ_t from some given data y_t by solving next equation:

$$\min_t \sum_{t=1} ((y_t - \tau_t)^2 + \lambda((\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1}))^2) \qquad (1)$$

so the residual $y_t - \tau_t$ is then commonly referred to as the business cycle component. This is actually a linear filter that requires previous specification of a parameter known as lambda (λ). Giving the form of the observation (annually, quarterly or monthly) this parameter tunes the smoothness of the trend i.e. penalizes the acceleration in the trend component relative to the cycle component. Many point that the parameter λ does not have an intuitive interpretation for

the user and that its choice is consider the main weakness of the HP filter. Non-the-less, HP filter has been applied in a number of relevant studies; Blackburn and Ravn (1992), De Arcangelis and Di Giorgio (1999), Franke (2006), etc.

According to Stock and Watson (1998) and Napoletano, Roventini and Sapio (2005), co-movements between variables are revealed through the cross-correlation of the cyclical component of each series with the cyclical component of real gross domestic product as a benchmark variable, which is thought to represent the business cycle. This is the correlation between x_t and y_{t+k}, where x_t is the filtered series and y_{t+k} is the k-quarter lead of the filtered real gross domestic product. A large positive correlation at $k = 0$ (i.e. around lag zero) indicates pro-cyclical behaviour of the series; a large negative correlation at $k = 0$ indicates counter-cyclical behaviour; and no correlation indicates acyclical behaviour of the series. A maximum correlation at, for example, $k = -1$ indicates that the cyclical component of the variable tends to lag the aggregate business cycle by one quarter. In other words, if the absolute maximum (or minimum) is achieved at some real gross domestic product lead, then the variable is denoted as *leading*, whereas it is called *lagging* in the opposite case[2]. Finally, *coincident* variables are those displaying the bulk of their cross-correlation with real gross domestic product at lag zero.

Second, in order to observe and evaluate conclusions from the previous analysis we introduced to concept of coherence i.e. synchronicity as a part of the *deviation cycle analysis*[3]. The usual interpretation given by scholars to the concept of synchronization between growth and business cycles relates to the pattern of growth between these countries rather than the magnitude of growth rates or the amplitude of the growth trend or business cycles as stated by Crowley and Schultz (2010). By synchronicity we always mean the similarity of movements in growth rates over time, so we have to be careful when we analyze convergence which presents the proximity of growth rates with growth rates of other observed country or unit. Many studies opt to calculate both indicators in order to serve better conclusions. An intensive work by Mink et al. (2007) led to a paper in 2012 which introduced new insight into business cycle coherence by measuring two separate indicators: a) *synchronicity* (φ_{ir}) and b) *similarity* (γ_{ir}). Within their study, coherence of the EU member country i and the benchmark r represented by the enlarging Euro area was measured:

$$\varphi_{ir}(t) = \frac{g_i(t)g_r(t)}{|g_i(t)g_r(t)|} \qquad (2)$$

and

$$\gamma_{ir}(t) = -\frac{n\,|g_i(t) - g_r(t)|}{\sum_{i=1}^{n} |g_i(t)|}. \qquad (3)$$

where $g_i(t)$ is the cyclical component of the analyzed output of a country i in time t and $g_r(t)$ refers to the cyclical component of the reference country r in time t. When averaged over a time interval and transformed to a uniform scaling, the synchronicity measure shows the fraction of time that the output gap of country i has the same sign as the output gap of the

[2] For deeper insight see Napoletano, Roventini and Sapio (2005) or Benazić and Tomić (2014).
[3] Deviation cycle analysis is concerned with phases of above and below trend rates of growth as it is known also as a growth cycle approach. Alternative measure is viewed as classical cycle approach.

reference cycle, whereas averaging similarity between individual countries and the reference over all *n* countries in the sample yields co-movement for the region as a whole (Mink et al., 2012). In general, synchronicity between the business cycle of an individual country and the reference cycle ranges between 1 and −1, while for co-movement these values are 0 and −n. Important feature of this measurement is 'right' reference cycle. Following the dilemmas in Mink et al. (2007) we adopted the same statistical *ex post* approach by selecting the cycle that lies the closest to all individual countries' cycles in the EU i.e. the median of all output gaps observed in that period. So we choose the median of all EU 28 member countries[4].

Quarterly data presenting macroeconomic variables for Slovenia were collected from International Financial Statistics and Eurostat for the period of 1992Q1 – 2013Q4. Data were seasonally adjusted using the Census X12 seasonal adjustment procedure. In order to extract the business cycle component that presents the stationary cycle of the variable we used smoothing parameter λ of 1,600 which is the standard value for quarterly frequencies. To test the integration properties we analyzed graphical displays of the variables and applied three unit root tests Augmented Dickey Fuller test - ADF (1979), Phillips-Perron test - PP (1988) and Kwiatkowski-Phillips-Schmidt-Shin test (1992). Generally, graphs and tests confirmed the absence of unit root in the observed variables[5] which is important property of detrended variables (see Benazić and Tomić, 2014). Variables included in the evaluation of cyclical properties of the Slovenian economy are: producer price index (**PPI**), consumer price index (**CPI**), harmonised index of consumer prices (**HCPI**), industrial production (**IND**), employment (**EMP**), real gross domestic product index (**GDP**), imports of goods (**IMP_G**) and exports of goods (**EXP_G**) for the period 1992Q1-2013Q4(Q4); final consumption expenditure (**CONS**), final consumption expenditure of general government (**GOV**), imports (**IMP**) and exports (**EXP**) of goods and services for the period 2000Q1-2012Q4. Coherence based measures are calculated with nominal values of output in millions of euros for the period 1995Q1-2014Q2 due to data availability.

4 Interpretation of the results

Here are some stylized facts on the business cycle positions. By interpreting cross-correlations with lags/leads between the real output (GDP) and selected variables (*Table 1.* in the *Appendix*) we can notice that most of the variables exhibit pro-cyclical leading behaviour. Interestingly, monetary variables suggest statistically insignificant and weak correlation to the output movements, only producer price index exhibiting relatively mediocre (significant) leading and pro-cyclical pattern. Slovenia is a part of the euro area, therefore its external and internal vulnerability depends on the EU's monetary policy. Since this monetary policy is mostly directed towards neutralization of shocks and the stability of financial system, we can say that Slovenia does not have important instrument of economic policy in their hand, yet the period of this global crisis certainly proved the audacity of European Central Bank who helped the European and therefore Slovenian economy not to lose its growth potential. There has been a small decrease in correlation of cyclical behaviour of the Slovenian GDP during post-crisis period, as Jazbec (2013) states, implicating that there has been a withdrawal of

[4] First we observed the possibility of reference 'output' cycle as the total EU28, total EU15, only Germany as economically strongest European country, EU28 median and the median of three countries important for Slovenian economy (Germany, Austria and Italy) for their trade relevance. Graphical display of the variables suggested almost similar movements (see *Appendix*) so we opted for the EU28 median analogously to Mink et al. (2012).

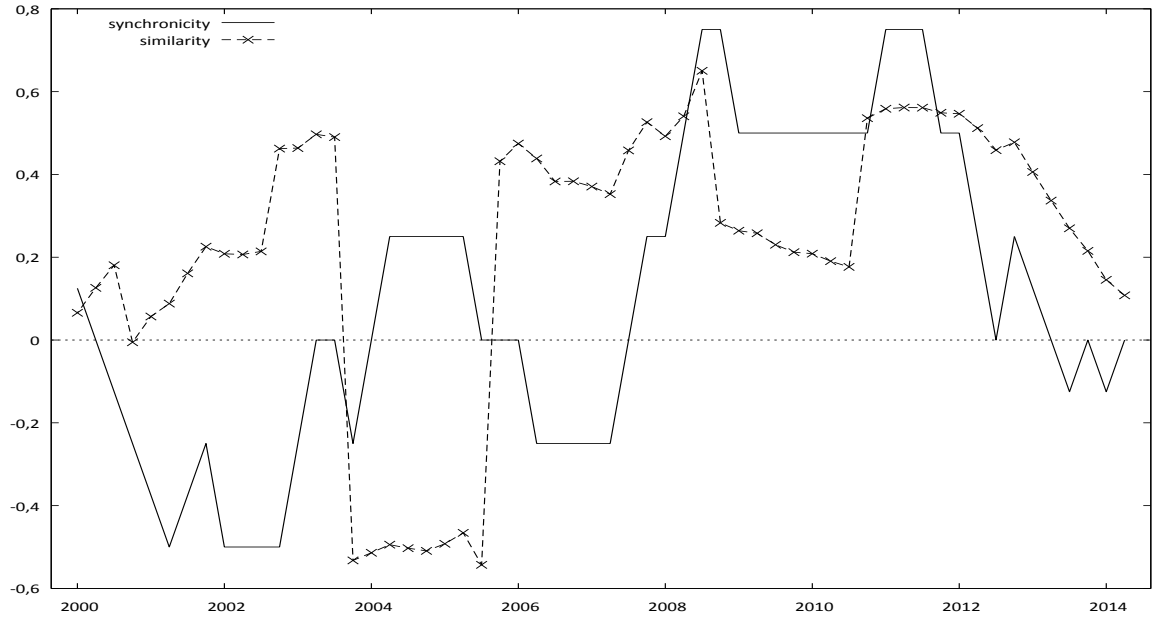
[5] Available upon request.

foreign funding for banks which could cause large fluctuations in credit and output in Slovenia. Such developments could have detrimental effect on the economy even though there exists very limited foreign ownership of the Slovenian banking sector. This argument could be used in explaining relative reduction in business cycle synchronization of the Slovenian economy.

Turning the attention to the real variables, we can notice similar pro-cyclical and leading behaviour but with much stronger statistically significant effect. As an exception we have industrial production that show relatively strong and statistically significant lagging behaviour suggesting that an increase in industrial production comes as a result of positive expectations of output growth and purchasing power. Variable employment suggests strong leading behaviour especially in the *t+2* period, meaning that the accountability of employed work force certainly can explain fluctuations in the output. Though cross-correlations show statistically insignificant and counter-cyclical behaviour of final consumption expenditure, graphical display indicate that we have certain pro-cyclical co-movements with the output. It suggests that business cycles in Slovenia are not manifested through real consumption. However, variable final consumption expenditure of general government indicate relatively strong, statistically significant and leading behaviour suggesting that Slovenia can still use its fiscal policy in an expansive manner. There is also strong, statistically significant and stable cross-correlation of output with export and import. Therefore, by influencing its export and import, Slovenia could determine or at least affect certain phase of business cycle as its EU synchronization process was well influenced by trade developments.

There are many reasons why coherence in movements in economic growth between (some) countries is economically relevant, as stated by Crowley and Schultz (2010), but currently for Slovenia, as a country that is a part of EU, the most important question is how similar movements in economic growth could indicate similar patterns in growth within the EMU. Following the methodology presented in *Section 3* we calculated two measures of coherence, namely the synchronicity and similarity between the Slovenian output gap and the output gap of EU28, and presented their eight-year moving averages in graphical form (*Figure 1.*).

Figure 1: Synchronicity and similarity of the Slovenian output gap *vs.* EU28median



Source: Authors' calculation.

Results and graph suggest that synchronicity and similarity levels fluctuated substantially over time, however synchronicity seems to be much less volatile than the similarity. Correlation between these two measures over time of 0,17% illustrates that synchronicity and similarity are in fact two different concepts that tend to change and fluctuate within time domain. This also means that deviations in business cycles and impact of different shocks have different effects on the pattern and amplitudes of growth in Slovenia which is indicative for economic policy reasoning. Overall conclusion is that both coherence measures increased within analyzed period, however their positive trend was somewhat different[6].

Synchronicity was rather week in the beginning, which is opposite conclusion to most of the studies that suggested that cyclical synchronization between Slovenia and the EU was already similar in some aspects due to a better preparation in joining the EU well before 2004. As the point of accession in the EMU was getting closer, Slovenia was achieving higher degree of synchronization with the EMU countries for GDP, industrial production and export (Stanisic, 2013). It indicates that Slovenia has relatively strong economic links with specific eurozone countries such as Germany and Italy which helped in this synchronization process. Following the EMU accession Slovenia was showing one of the highest average estimates of business cycle synchronization with the EU, especially with the countries in euro area. Explanation for the rise in business cycle synchronicity can be found in the stronger trade and financial linkages with the EU and the increase in the symmetry of macroeconomic shocks across countries. Recent crises resulted in drastic decline in cycle synchronicity probably due to austerity measures and a decline in general consumption. Weak demand side could be presenting great obstacle for higher degree of synchronization with the EU for Slovenia. On the other hand, similarity seems to be relatively stable over time with only serious decrease around the EU accession point probably due to last preparations which included trade transaction costs and financial information costs, tendencies towards institutional quality, financial deepening, more flexible labour and product markets etc. After the 2005, similarity measure tends to follow synchronicity measure in trend perspective, which is especially seen following the start of the crisis.

As we previously pointed, likely reasons for recent, thought slight, decoupling of the business cycle in Slovenia should not be sought in trade developments, but in strong cyclical reduction in financing of both households and firms with the withdrawal of foreign funding (see Jazbec, 2013). Again, though Slovenian banking sector is only partially in foreign ownership, such developments can have feasible negative effects. This could present additional shock to the already weak demand side and real activity of the Slovenian economy. The renewed uncertainty, coupled with slow export growth and low investment means that there is no room for ambivalence, hence policy responses must be both immediate and resolute. Unclear responses could add to market uncertainty and magnify economic and social tensions. *Ditto*, it indicates that the fast convergence with other EU member states is not an easy process. Global crisis certainly had great negative effect upon the Slovenian and euro area (and the EU28) business cycle coherence, as synchronicity and similarity measures decreased similar to many other Central and East European countries meaning that the impact of Euro introduction upon the business cycle coherence was not as high as expected which supports the general findings of other related studies (see Najman and Rozmahel (2013) for example). Furthermore, phases of decoupling and recoupling of business cycle co-movements alter

[6] Many studies came to conclusion that Slovenia, among other countries such as Hungary and Poland, showed strong improvement in cyclical correlations to old EU countries as moving from 1993-1999 to 2000 and on.

frequently, but a clear upward or downward trend is also barely observable in the average degree of business cycle synchronisation in the Euro area in last twenty years (Van Aarle et al., 2008).

5 Beyond conclusion

The academic literature, especially in Europe as well as the media press is full of references and studies that imply the importance of the synchronisation of links between economies. The goal of this paper was to look into business cycle aspects of the Slovenian economy *vis á vis* European Union in terms of coherence measures in order to evaluate development perspectives. The main scientific contribution reflects in generalizabilty of conclusions and their argumentative character for such could bear important implications for the Slovenian macroeconomic management, especially for sustainable development perspective. The external environment has significantly worsened recently and will likely remain uncertain for a prolong period of time. Recent events suggest that access to a large EU market and the political stability factor, while crucial, are not sufficient to achieve country development by itself. Namely, EU membership generates both opportunities and challenges that need to be timely recognized. Aligned economies i.e. synchronization tendencies is certainly a factor that could assure better development framework. In order to evaluate business cycle movements and coherence concepts within the Slovenian economic perspective we applied two distinctive methods.

First, we used output gap cross-correlation in order to present some stylized facts on the business cycle positions. General conclusion on this part suggests that most of the selected variables exhibit pro-cyclical leading tendencies. Next, we evaluated two coherence measures that take into account, both differences between cycle amplitudes as well as synchronicity of cycles. This is important because cycle amplitude component of business cycle similarity is generally overlooked. Overall conclusion is that both coherence measures increased within analyzed period, yet their trend developments were rather intriguing. Recent crisis showed negative effects upon synchronicity and similarity behaviour of the Slovenian economy, thus a clear – positive or negative – "euro effect" on synchronisation does not appear in the latest available data. However, we cannot talk about clear decoupling phase for Slovenia since the trade developments and financial flows *de facto* caused greater synchronization in economic growth between Slovenia and the EU, especially after the introduction of the euro, only recent crisis obstructing this pattern in some manners.

Although the results of some studies suggested post 1990s as the time in which business cycles in the euro area have become more similar, the business cycles of many euro countries are still substantially out of sync. Since we expect in the future that the implementation of monetary policy in the enlarged EMU is to be more successful if the member countries have synchronized business cycle, the development of co-movements in cycle synchronicity and amplitude of the Slovenian economy is of utmost importance for its macroeconomic management. Though we lately witness some de-synchronization processes, stable monetary policy conducted by the European Central Bank did not amplify negative trends in business cycle developments in Slovenia, therefore it presented close substitute for national monetary policy. Further positive developments on the demand side in Slovenia with optimistic trends on the whole European market should boost more cooperative international system that will be weighed against the expansion of production capabilities, interaction between consumption and investment, fiscal consolidation, improved quality of life and sustainable development. In

this manner the concept of synchronization will be building on its importance and relevance.

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Appendix

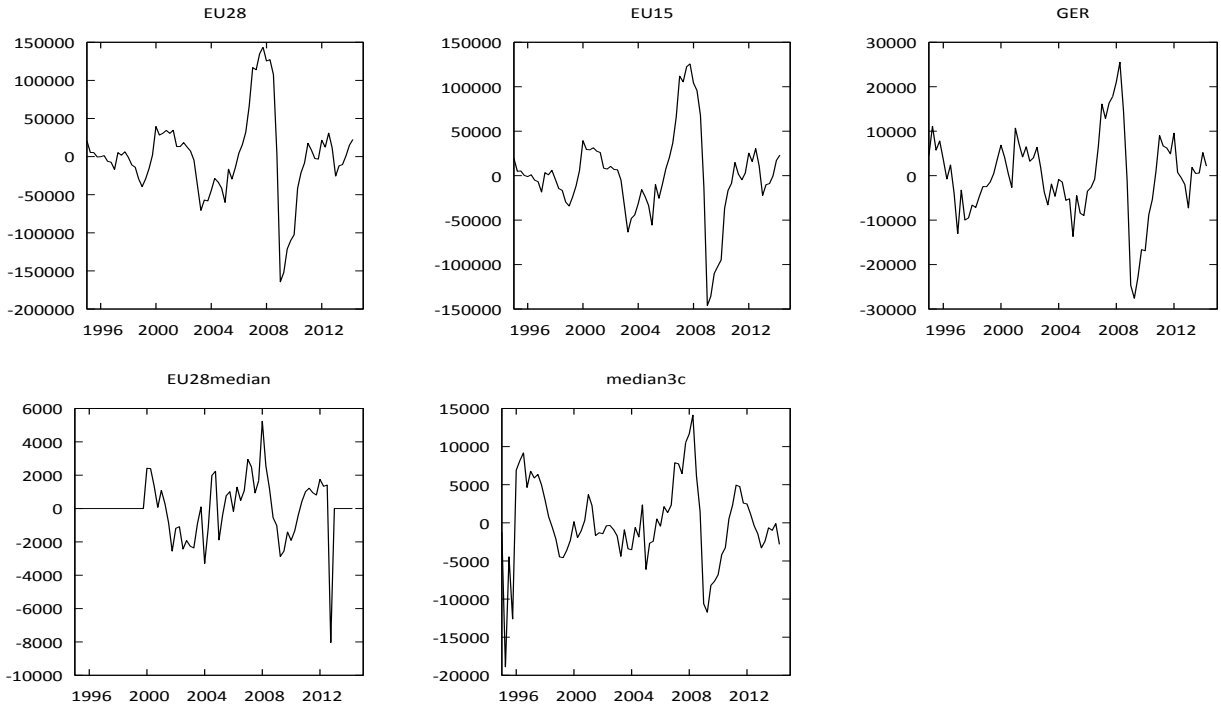
Table 1: Cross-correlation to GDP with lags and leads up to 4 periods (real variables)

Variable	t-4	t-3	t-2	t-1	t-0	t+1	t+2	t+3	t+4
PPI	-0,08	-0,07	-0,07	-0,07	**0,29**	**0,41**	**0,55**	-0,08	-0,07
CPI	-0,16	-0,14	-0,10	-0,05	0,02	0,03	0,05	0,02	0,02
HCPI	-0,02	-0,02	-0,01	0,00	0,02	0,01	0,01	0,00	0,01
IND	**0,68**	**0,49**	**0,32**	0,17	0,05	-0,06	-0,11	-0,13	-0,14
EMP	-0,09	-0,09	-0,10	-0,10	**0,35**	**0,51**	**0,70**	-0,09	-0,08
IMP_G	-0,12	-0,11	**0,34**	**0,79**	**0,60**	**0,23**	-0,07	-0,06	-0,05
EXP_G	-0,12	-0,11	**0,35**	**0,82**	**0,61**	**0,23**	-0,09	-0,07	-0,06
IMP	-0,16	-0,16	-0,01	**0,20**	**0,43**	**0,59**	**0,81**	**0,44**	0,10
EXP	-0,16	-0,17	0,00	**0,20**	**0,44**	**0,62**	**0,84**	**0,43**	0,08
CONS	0,03	0,03	-0,01	-0,01	-0,03	-0,03	-0,02	-0,03	-0,05
GOV	-0,17	**-0,19**	-0,03	0,15	**0,39**	**0,54**	**0,80**	**0,44**	0,14

**bold number denotes 1%, 5% or 10% significance levels respectively*

Source: Authors' calculation.

Figure 2: Alternative variables for reference business cycle



Source: Authors' calculation.