



# Littera Scripta

1/2014



# LITTERA SCRIPTA

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<http://portal.vstecb.cz/publishingportal/littera-scripta>

ISSN 1805-9112 (Online)  
Datum vydání: červen 2014  
Periodicita: 2x ročně

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České Budějovice, červen 2014

Za redakční radu  
prof. Ing. Jan Váchal, CSc.

# INTRODUCTORY WORD

Dear readers,

you certainly know, that in the last year the Methodology in the evaluation of research organisations was changed and it brought a lot of changes. One of them is the change of publication activities evaluation, that led to the great decline of authors interest at publishing in reviewed nonimpacted journals. For this reason we offer you a visibly lower amount of papers. Nevertheless we believe, that their content will bring you new, interesting and enlightening information. In connection to the decline of technically oriented authors' interests the decision of journal transformation was made and starting with the next issue only articles with economical topics will be published. Specifically it concerns with the problematic of business economics, management and marketing and moreover on public sector economy, management, governance and administration. We believe, that the authors will find the way back to our journal very soon and we would again be able to bring you a great amount of original knowledge and information.

I would like to thank you for the loyalty you have shown to the journal *Littera Scripta* and I am pleased that despite all the changes brought about by the new methodology in the evaluation of research organizations, we managed to prepare this issue for you in the usual time.

I wish you pleasant reading, and I look forward to the continuous regular meeting of the journal *Littera Scripta*.

České Budějovice, June 2014

In the name of the editorial board  
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Do čísla 1/2014 byly zařazeny 4 recenzované příspěvky od 8 autorů z 6 pracovišť. /

In issue 1/2014 4 reviewed articles written by 8 authors from 6 institutions were included.

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Počet doručených článků / Number of articles received: 11

Počet článků vyřazených v 1. kole recenzního řízení / Number of articles rejected in 1<sup>st</sup> round of review proceedings: 3

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### Recenzní rozhodnutí / Review conclusions

Počet zpracovaných recenzí / Number of reviews delivered: 17

- z toho recenzováno recenzentem s titulem doc. nebo prof. / from which was reviewed by reviewer with Doc. or Prof. degree: 12 (70,6 %)

	Recenzenti s doc. či prof. Reviewers with Doc. or Prof. degree	Ostatní Other	Celkem In total
Přijato beze změn Published without changes	3	0	3
Přijato, doporučeno zohlednit navrhované úpravy Published, suggested considering some remarks	4	2	6
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# Optimal Portfolio of Chosen Stocks of the Prague Stock Exchange

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## Abstract

The aim of the article is to assemble an optimal portfolio of chosen stocks of the Prague Stock Exchange. The Markowitz portfolio model is used. At first, Pearson correlation coefficients and covariance are calculated for the stocks ČEZ, KOMERČNÍ BANKA, TELEFÓNICA, UNIPETROL, NWR and PX Index in order to find the dependence measure from 2003–2012. These values are presented in a correlation matrix and covariance matrix. Yield, risk and yield to risk ratios are calculated for stocks and PX Index. The dependence between yield and risk of stocks as well as yield and risk of portfolios are found. Stocks have different weights in a portfolio. A set of possible portfolios and a set of efficient portfolios are assembled for various combinations of five-component stock portfolios. Based on that, an optimal portfolio is assembled. This article brings a method that can be used by investors and other subjects of the financial market while deciding to what stocks to invest in.

**Keywords:** management stock portfolio, market portfolio, Stock Exchange index, Stock Exchange

## Introduction

Many investors invest on financial markets in various securities including stocks. Stocks belong to rather risky securities. Making investment decisions, investors try to find the risk related to investments in stocks. Kohout (1998) states that risk of stock price change is determined by standard deviation that takes account of stock price trend in time over a period. Investors find both risk and yield related to investing in stocks. According to Rejnuš (2008), the total yield is the sum of current and capital yield. Rejnuš (2001) presents that capital yield depends on achieved investment management results. To estimate yield, static methods and dynamic methods are usually used. While static methods do not take account of time factor, dynamic ones do.

In creating a portfolio, all investors are similarly motivated to combine stocks held in order to realize maximum yield with minimum risk. In the case of only partial positive correlation of stocks in a portfolio, possible diversification leads to a reduction of risk. The size of reduction depends on statistical

dependence between number of stocks and flow of income from investments. The higher statistical dependence is and the lower number of investments, the lower is the profit as a result of diversification. Various sets of portfolios have been described and analysed. A set of possible portfolios includes all possible combinations of portfolios.

Markowitz (1952) describes the set of efficient portfolios as such a set of portfolios with returns that are maximized for a given level of risk based on the mean-variance portfolio construction. Sharpe (1964) considers the market portfolio to be a portfolio consisting of a weighted sum of every asset in the market. On an efficient market where all information is immediately reflected in stock price change, investing in a market portfolio is optimal for many investors. León (2008) focuses on Markowitz's efficient portfolio optimization. He describes assumptions of this mean-variance framework like a static correlation matrix and normality of returns. The inconvenience of using an estimated correlation matrix typical of tranquil and the choice of the risk metric limits this framework. Almgren and Chriss (2004) extend Markowitz's notion of an efficient portfolio, specifically they introduce a preference relation on the set of possible portfolios. They also define an efficient portfolio as one which is most preferable among those with a given level of risk. Knowing expected returns, final optimal portfolios are theoretically superior all other possible portfolios and return Markowitz optimal portfolios.

The optimal portfolio is usually assembled based on choice of set of efficient portfolios. Investors prefer an optimal portfolio for its most favourable ratio of yield and risk. Cipra (2005) explains the attitude of investors to risk by means of indifferent curves. Investors consider these connecting lines from their perspective as identically acceptable. In the case of an optimal portfolio, indifferent curve of investor is the tangent of a set of efficient portfolios. The final choice of set of efficient portfolios depends, according to Levy and Sarnat (1999), on preferences of investors. This choice enables investors to achieve the highest indifferent curve, because the higher the indifferent curve, the higher utility investors will achieve. Brada (1996) presents that three basic assumptions should be ensured from the investor's view while assembling an optimal portfolio: to achieve maximum yield, maximum liquidity and minimum risk related to portfolio. The market portfolio is the only optimal portfolio to what all investors can invest in. In the case of an efficient market, all investors have the same opportunities as to what securities to invest in. Moreover, all investments are fairly valued within the market equilibrium. Bai, Liu and Wong (2010) focus on Markowitz's mean-variance portfolio optimization. They develop bootstrap estimators for the optimal return and its asset allocation. The PX Index as an official index of the Prague Stock Exchange is a price-weighted index. Kohout (2000) presents that investing in stock market indexes in the long-term horizon brings to investors an optimal combination of yield and risk.

Some authors focus on the way of creating an optimal portfolio and an efficient portfolio which contains stocks of the Prague Stock Exchange. Portfolios created in different ways are compared. Husárová (2012) examines daily prices of 14 stocks from 2009–2012 and she creates portfolios in several ways.

In detail, according to minimum risk, maximum yield-to-risk ratio and maximum Sharpe ratio. Weekly prices of 5 stocks from 2005–2010 are analysed by Zajíček (2011). He creates portfolios according to minimum risk, minimum risk together with a necessary level of yield and Cutoff rate model. Roušavý (2010) measures daily prices of 14 stocks of the Prague Stock Exchange, similarly like previous authors. He uses the period 2009–2010 and creates offensive, defensive and mixed portfolios. The creation of the optimal portfolio and efficient portfolio are at the centre of attention of Kislingerová (2011) and Fotr and Hnilica (2009), who show how the yield-to-risk could be used to create such portfolios.

The aim of the article is to assemble an optimal portfolio of chosen stocks of the Prague Stock Exchange between 2003–2012. To assemble the portfolio, modern portfolio theory is applied, specifically the Markowitz portfolio model. Applying this model, a set of possible portfolios, a set of efficient portfolios in the Markowitz sense and Markowitz optimal portfolio are assembled. The reason, why the author focuses on this topical interesting problematic, why he writes the article and uses the chosen method is that stock portfolios are assembled by means of the presented method of mostly foreign stock markets.

## Materials and Methods

At first, five stocks of the Prague Stock Exchange are chosen. Data needed for empirical analysis are founded through Patria Online, a.s. (2013) and Prague Stock Exchange (2013). In detail, historical stock prices and PX Index values in quarterly periodicity are founded.

The statistical dependence between stocks is found by means of several formulae presented by Brada (1996). Pearson correlation coefficients are calculated as follows:

$$\rho_{ij} = \frac{\sum_{t=1}^N (i_t - E(i))(j_t - E(j))}{\sqrt{\sum_{t=1}^N (i_t - E(i))^2 \cdot \sum_{t=1}^N (j_t - E(j))^2}}$$

where  $\rho_{ij}$  is the Pearson correlation coefficient of  $i$ -th and  $j$ -th stock,  $N$  is number of trading days,  $i_t$  is yield change of  $i$ -th stock in time  $t$ ,  $j_t$  is yield change of  $j$ -th stock in time  $t$ ,  $E(i)$  is mean yield of  $i$ -th stock and  $E(j)$  is mean yield of  $j$ -th stock. The Pearson correlation coefficient relates to linear function, which describes the relation between stock prices. Covariance could be considered to be a linear gauge of dependence. In detail, covariance measures how much two stock prices change together. When the covariance is normalized, the correlation coefficient is obtained. Markowitz (1952) uses this coefficient also to create a diversified portfolio.

Covariances are calculated as follows:

$$C_{ij} = \beta_i \cdot \beta_j \cdot \sigma^2$$

where  $C_{ij}$  is the covariance of  $i$ -th and  $j$ -th stock,  $\beta_i$  is the beta coefficient of  $i$ -th stock,  $\beta_j$  is the beta coefficient of  $j$ -th stock and  $\sigma^2$  is the second power of standard deviation, which is defined subsequently.

Risk, specifically the mentioned standard deviation of stock price is calculated as follows:

$$\sigma = \sqrt{\sum_{t=1}^N \frac{(R_t - E(R))^2}{N - 1}}$$

where  $\sigma$  is the standard deviation,  $N$  is number of trading days,  $R_t$  is stock price and  $E(R)$  is average stock price during the period. Musílek (2011) describes this risk as the probability that return on an investment will be different from the expected return.

Yield, risk and yield to risk ratio of stocks are calculated. Yield, specifically relative capital yield is calculated as follows:

$$Y_{itk} = \frac{P_{it} - P_{it-k}}{P_{it-k}}$$

where  $Y_{itk}$  is stock price growth of  $i$ -th stock during interval  $(t - k, t)$ ,  $P_{it}$  is stock price of  $i$ -th stock in time  $t$  and  $P_{it-k}$  is stock price of  $i$ -th stock in time  $t - k$ .

Yield, risk and yield to risk ratio of portfolios are also calculated. Yield of  $n$ -component stock portfolios, specifically relative capital yield is calculated as follows:

$$R_p = \sum_{i=1}^n w_i \cdot R_i$$

where  $R_p$  is yield of  $n$ -component stock portfolio,  $n$  is number of stocks in portfolio,  $w_i$  is weight of  $i$ -th stock in portfolio and  $R_i$  is yield of  $i$ -th stock.

Risk of two-component stock portfolios, specifically standard deviation of portfolios is calculated as follows:

$$\sigma = \sqrt{(w_1^2 \cdot \sigma_{11} + 2 \cdot w_1 \cdot w_2 \cdot \sigma_{12} + w_2^2 \cdot \sigma_{22})}$$

where  $\sigma$  is the standard deviation of  $n$ -component stock portfolio,  $n$  is number of stocks in portfolio,  $w_i$  is weight of  $i$ -th stock in portfolio,  $w_j$  is weight of  $j$ -stock in portfolio and  $\sigma_{ij}$  is covariance of  $i$ -th and  $j$ -th stock.

Using presented formulas, a set of possible portfolios, a set of efficient portfolios and an optimal portfolio is assembled.

A set of efficient portfolios in the Markowitz sense is expressed as follows:

$$E_M = E_r \cap E_S$$

where  $E_M$  is set of efficient portfolios in the Markowitz sense,  $E_r$  is set of portfolios with minimum risk (set of efficient portfolios in the Sharpe sense) and  $E_S$  is set of portfolios with maximum yield.

Portfolio diversification is measured by the Herfindahl Index as follows:

$$HI = 1 - \sum_{i=1}^n w_i^2$$

where  $HI$  is the Herfindahl Index,  $n$  is number of stocks in portfolio and  $w_i$  is weight of  $i$ -th stock in portfolio.

## Results

First, five stocks of the Prague Stock Exchange are chosen. Trading volumes in CZK from 2003–2012 ordered from the highest are found. Tab. 1 reports the first 10 trading volumes ordered from the highest.

Table 1: Top 10 Trading Volumes on the Prague Stock Exchange during 2003–2012

Stock	Trading volume (CZK)
<b>ČEZ</b>	1 962 555 878 883.99
<b>Komerční banka</b>	904 975 334 830.32
<b>Telefónica</b>	653 995 085 234.33
<b>Erste bank</b>	500 779 637 052.34
<b>Unipetrol</b>	201 690 774 821.18
<b>NWR</b>	154 574 174 287.86
<b>CETV</b>	127 756 125 512.69
<b>Philip Morris</b>	105 450 515 551.82
<b>Pegas Nonovens</b>	31 602 370 464.86
<b>VIG</b>	8 371 222 216.03

Source: Own calculations using Patria Online, a.s. (2013)

ERSTE BANK is not chosen, because possible inclusion of two stocks from the same industry (here KOMERČNÍ BANKA and ERSTE BANK) to the portfolio implies distortion of results. Chosen stocks should be independent of each other. So that following five stocks are chosen: ČEZ, KOMERČNÍ BANKA, TELEFÓNICA, UNIPETROL and NWR.

Then, statistical dependence between stocks is found. The correlation matrix of stocks is reported in Tab. 2.

Table 2: Correlation Matrix of Stocks

Stock	ČEZ	Komerční banka	Telefónica	Unipetrol	NWR	PX
ČEZ	1.00	0.71	0.80	0.87	0.83	0.79
Komerční banka	0.71	1.00	0.57	0.72	0.37	0.69
Telefónica	0.80	0.57	1.00	0.88	0.57	0.93
Unipetrol	0.87	0.72	0.88	1.00	0.75	0.92
NWR	0.83	0.37	0.57	0.75	1.00	0.90
PX	0.79	0.69	0.93	0.92	0.90	1.00

Source: Own calculations using Patria Online, a.s. (2013)

The higher the correlation coefficient between two stocks, the stronger is dependence between these stocks. In the case of a correlation coefficient close to 1.00, yields of two stocks change similarly. It means that when the first is increasing, the growth of the second is almost the same. On the contrary, when the first is decreasing, the decrease of the second is almost the same. When correlation coefficient equals to 1.00 there is a linear dependence with positive direction.

Correlation coefficients 1.00 are in Tab. 2 only at main diagonal of this symmetric matrix. This fact has influence on value of correlation coefficients. The PX Index is mostly influenced by TELEFÓNICA. The lower is dependence between stocks and the higher is number of stocks, the higher is possible profit followed from diversification.

To calculate risk the of portfolios, the covariance matrix is found. This covariance matrix, that is similarly as correlation matrix symmetric, is reported in Tab. 3.

Table 3: Covariance Matrix of Stocks

Stock	ČEZ	Komerční banka	Telefónica	Unipetrol	NWR	PX
ČEZ	118 308	162 796	22 258	22 076	13 243	98 764
Komerční banka	162 796	444 138	30 381	35 502	22 038	167 505
Telefónica	22 258	30 381	6 508	5 193	1 896	27 124
Unipetrol	22 076	35 502	5 193	5 406	2 375	24 556
NWR	13 243	22 038	1 896	2 375	10 869	16 244
PX	98 764	167 505	27 124	24 556	16 244	130 953

Source: Own calculations using Patria Online, a.s. (2013)

Dispersions of parameters are at the main diagonal of Tab. 3. Elton, Gruber, Brown and Goetzmann (2006) describe covariance as a statistical indicator derived from dispersion measuring to what extent two parameters move similarly. High covariances are measured by combinations of KOMERČNÍ BANKA with other stocks or with a PX Index. Dispersion of KOMERČNÍ BANKA is distinctly higher than dispersions of other stocks and PX Indexes.

Then, yield, risk and yield to risk ratio of stocks are founded. They are reported in Tab. 4.

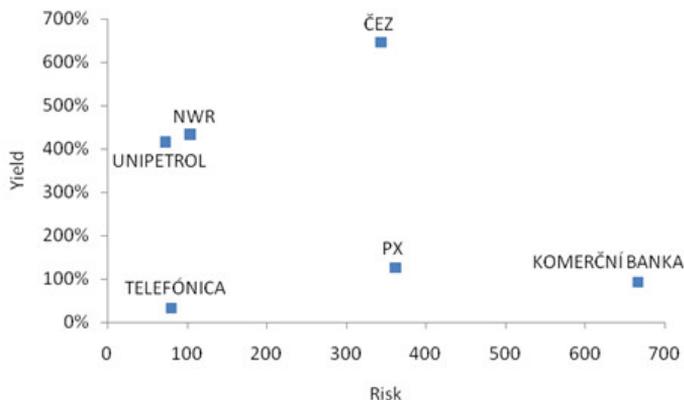
Table 4: Yield, Risk and Yield to Risk of Stocks

Indicator	ČEZ	Komerční banka	Telefónica	Unipetrol	NWR	PX
Yield	646 %	92 %	32 %	415 %	434 %	125 %
Risk	344	666	81	74	104	362
Yield to Risk	1.88 %	0.14 %	0.40 %	5.61 %	4.17 %	0.35 %

Source: Own calculations using Patria Online, a.s. (2013)

It is clear that all yields are positive. The trend of whole market represented by the PX Index in the chosen period is in terms of direction similar to the trend of stock prices of all five stocks. Maximum yield is found by ČEZ, while maximum risk by KOMERČNÍ BANKA. The dependence between yield and risk of stocks is illustrated in Graph 1.

Graph 1: The Dependence between Yield and Risk of Stocks

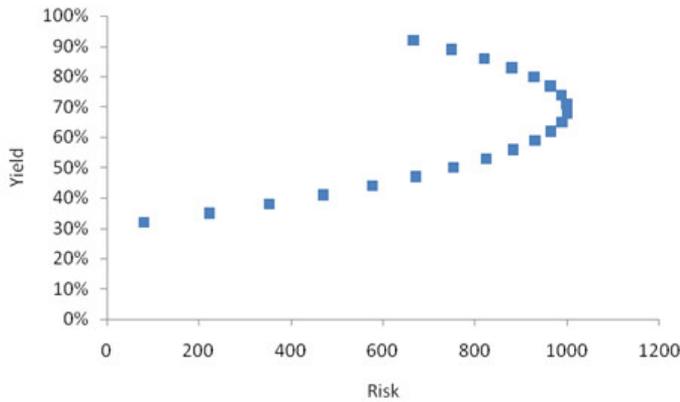


Source: Own calculations using Patria Online, a.s. (2013)

It is clear that investment to KOMERČNÍ BANKA brings lower yield and a higher risk than investment to UNIPETROL, NWR and ČEZ. These three stocks are dominant assets in relation to KOMERČNÍ BANKA. Investment to them brings also higher yield and a lower risk than investment to the PX Index. Possible investment to the other two stocks, specifically KOMERČNÍ BANKA and TELEFÓNICA will be diversified according to weights of stocks.

Then yield and risk of two-component stock portfolios are calculated. Weights of individual stocks in portfolios are either 5 % or multiples of it. Progression 5 %, 10 % etc. affords sufficient and clearly arranged ways how to present individual differences in portfolios. 21 portfolios are assembled by combinations of different weights of stocks in the portfolios. The dependence between yield and risk of portfolios is illustrated in Graph 2.

Graph 2: The Dependence between Yield and Risk of Portfolios



Source: Own calculations using Patria Online, a.s. (2013)

Also the set of possible portfolios is illustrated in Graph 2. It is clear that both yield and risk related to different portfolios are also different. Thus, possible weight changes of stocks in portfolios lead to changes of yield and risk of portfolios.

The set of efficient portfolios is a subset of the set of possible portfolios. Yield to risk ratios of efficient portfolios must be higher than yield to risk ratio of PX Index. Based on values of PX Index presented in Tab. 4, the yield to risk ratio equals to 0.35 %. Tab. 5 contains indicators related to set of possible portfolios sorted in ascending order for KOMERČNÍ BANKA weight in portfolio.

Table 5: Indicators Related to Set of Possible Portfolios

Komerční banka weight in portfolio	Telefónica weight in portfolio	Portfolio yield	Portfolio risk	Yield to risk ratio	Herfindahl Index
0 %	100 %	32.08 %	80.67	0.40 %	0.00 %
5 %	95 %	35.07 %	222.47	0.16 %	9.50 %
10 %	90 %	38.06 %	352.42	0.11 %	18.00 %
15 %	85 %	41.05 %	470.53	0.09 %	25.50 %
20 %	80 %	44.04 %	576.80	0.08 %	32.00 %
25 %	75 %	47.03 %	671.23	0.07 %	37.50 %
30 %	70 %	50.02 %	753.81	0.07 %	42.00 %
35 %	65 %	53.01 %	824.55	0.06 %	45.50 %
40 %	60 %	56.00 %	883.44	0.06 %	48.00 %
45 %	55 %	58.98 %	930.50	0.06 %	49.50 %
50 %	50 %	61.97 %	965.71	0.06 %	50.00 %
55 %	45 %	64.96 %	989.07	0.07 %	49.50 %
60 %	40 %	67.95 %	1000.60	0.07 %	48.00 %
65 %	35 %	70.94 %	1000.28	0.07 %	45.50 %

70 %	30 %	73.93 %	988.12	0.07 %	42.00 %
75 %	25 %	76.92 %	964.11	0.08 %	37.50 %
80 %	20 %	79.91 %	928.26	0.09 %	32.00 %
85 %	15 %	82.90 %	880.57	0.09 %	25.50 %
90 %	10 %	85.89 %	821.04	0.10 %	18.00 %
95 %	5 %	88.88 %	749.66	0.12 %	9.50 %
100 %	0 %	91.87 %	666.44	0.14 %	0.00 %

Source: Own calculations using Patria Online, a.s. (2013)

It is clear that the set of efficient portfolios contains only the first portfolio in Tab. 5. Only in this case is the yield to risk ratio higher than 0.35 %. Similarly to Graph 2, increasing the yield to 32.08 % higher, the risk of portfolios of the set of possible portfolios increases from 80.67 to 1000.60 and later decreases to 666.44. Portfolio diversification is expressed by the Herfindahl Index. Increase of this Index is connected with decrease of the yield to risk ratio and vice versa.

The optimal portfolio is the efficient portfolio with the highest yield to risk ratio. Investments to UNIPETROL, NWR and ČEZ could be considered to be efficient, because their yield is higher and their risk is lower than corresponding values of the PX Index. Moreover, their yield to risk ratio is higher than 0.35 %. Based on Tab. 5, investment only to TELEFÓNICA leads also to yield to risk higher than 0.35 %. Optimal portfolio consists of UNIPETROL (weight 47 %), NWR (35 %), ČEZ (16 %) and TELEFÓNICA (2 %). Weights of these stock in an optimal portfolio are derived of corresponding yield to risk ratios presented in Tab. 4.

## Discussion

In the context of similarly focused empirical studies, the composition of set of possible portfolios, set of efficient portfolios and optimal portfolio depends on many factors chosen within assembling. Such factors are the choice of security (stocks are in this article), market portfolio (stock market indexes or risk-free assets), stock market, historical period and number of portfolios assembled of different weights and other factors. Given the obligation of portfolio managers in some countries to hold at most 20 % of one stock in a portfolio also the potential limit of one stock weight in portfolio has certain influence on composition. Financial analysts could assemble optimal portfolios for investors differently averse to risk, especially for conservative, neutral and aggressive investors.

Low liquidity in the Prague Stock Exchange may lead to such values of correlation coefficients, covariances, yields and risks of stocks, which are not too comparable with the values obtained by analysis of high liquidity stock markets. In general, low liquidity may lead to certain distortion of calculated values. Thus, deduced findings need not correspond with results of the most of empirical studies, which are focused on modern portfolio theory.

In the opinion of the author, further research in this field can go in several directions. Based on presented factors, a method could be modified. Expected values in the future could be calculated instead of historical values from the

past. There are several ways how to estimate expected values. Quantitative analysis examines the development of ratio indicators and the horizontal or vertical analysis. Expected values could be estimated based on historical values. Econometric approach proceeds from knowledge of factors having an impact on expected values. These tools of financial analysis are used within the company analysis, which belongs, together with macroeconomic analysis and industry analysis, among parts of the fundamental analysis. Long-term fundamental analysis assumes, in contrast to short-term technical analysis, the existence of overvalued or undervalued stocks. Tools of the technical analysis like candlestick charts, Elliot waves, Bollinger bands and others could be used to for stock timing. Thus, investors can find when they should buy or sell stocks. Fundamental and technical analysis could be considered to be specific cases of investment analysis. In general, the aim of the investment analysis is to examine and assess important market trends, earnings ratios and other indicators to determine a suitable investment strategy.

## Conclusion

The article was focused on the assembling of an optimal portfolio of chosen stocks of the Prague Stock Exchange. To find dependence among stocks ČEZ, KOMERČNÍ BANKA, TELEFÓNICA, UNIPETROL, NWR and PX Index between 2003–2012, correlation and covariance matrixes were presented. Yield, risk and yield to risk ratios were measured, too. The dependence between yield and risk of stocks and the dependence between yield and risk of portfolios were illustrated. Using different weights of stocks in the portfolio, a set of possible portfolios and set of efficient portfolios as its subset were assembled. Weight of stock in the portfolio, portfolio yield and portfolio risk were presented for all stocks from a set of possible portfolios. Portfolio diversification was expressed by the Herfindahl Index. Based on results, the author found that investments to UNIPETROL, NWR and ČEZ could be considered to be efficient.

Highlighting to the contribution of this article, investors and other subjects of the financial market could use the presented method when they look for an optimal investment opportunity. This way will make their choice easier. Using the analysis of the dependence between yield and risk of various portfolios these subjects could find such an investment portfolio which is for them more attractive to investing than a market portfolio.

This article has been created within the research project IGA 28/2013 of Mendel University in Brno “Stock markets sensitivity to information in period after the financial crisis”.

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## Optimální portfolio z vybraných akcií obchodovaných na pražské Burze cenných papírů

Cílem článku je sestavení optimálního portfolio z vybraných akcií pražské Burzy cenných papírů. Je použit Markowitzův model portfolio. V rámci časového období 2003–2012 jsou nejdříve za účelem zjištění míry vzájemné závislosti vypočteny pro akcie ČEZ, KOMERČNÍ BANKA, TELEFÓNICA, UNIPETROL, NWR a burzovní index PX Pearsonovy korelační koeficienty a kovariance. Tyto hodnoty jsou znázorněny v korelační a kovarianční matici. Pro akcie a index PX jsou vypočteny výnosnosti a rizikovitosti. Je zjištěna závislost mezi výnosností a rizikovitostí akcií i mezi výnosností a rizikovitostí portfolio. Akcie mají v portfolio různou váhu. Pro různé kombinace akciových portfolio je sestavena množina přípustných portfolio a množina efektivních portfolio. Na základě toho je sestaveno optimální portfolio. Přínosem článku je prezentace způsobu, který mohou investoři a další subjekty na finančním trhu použít při rozhodování o tom, do jakých akcií budou investovat.

**Klíčová slova:** akciové portfolio, tržní portfolio, burzovní index, burza cenných papírů

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GOTTWALD, R. Optimal Portfolio of Chosen Stocks of the Prague Stock Exchange. *Littera Scripta*. 2014, 7(1), 12–24. ISSN 1805-9112.

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# Contribution to the Formulation of Economically Efficient Subsidy Policy in the Area of Small Hydro Power Plants

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## Abstract

This paper analyzes the economic aspects of subsidy policy in the area of small hydro power plants. It confronts the current practice with the theory and proposes an economically effective solution. It is the first of a series of contributions devoted to providing subsidies to producers of renewable energy to which, among others, belong running water, biofuels, wind and solar radiation. It is based on the results of three case studies dealing with the analysis of the economic efficiency of small hydro power plants, which are solved by the “case-based reasoning” approach. The first two studies relate to the already completed and operating hydro power plants on the rivers Sázava and Litavka in the Czech Republic. Their parameters and other required data are accessible at <http://www.eis.cz>. The third analyzed project is in the planning stage and has not yet been implemented or subsidized. Calculations are based on budgeted data and are used for demonstration and illustration of the proposed criteria of the effective economic subsidy policy.

**Keywords:** natural resource, economic resource, renewable resource, payback period, NPV, IRR, economic efficiency, subsidy policy

## Introduction

As we know the general economic view of all sources, both non-renewable (such as oil and natural gas) and renewable (of which the renewable energy sources play a particularly important role – rivers, biofuels, wind, solar radiation, etc.), distinguishes between the term “natural resource” and “economic resource”. Any “natural” resource becomes economically attractive and thus “economic” only if it fulfills the following two conditions:

1. *There are technologies that enable the obtaining (mining) and utilization of a natural resource;*

*2. Existing prices and conditions enable the economically meaningful usage of the resources.*

In the case of today's essential non-renewable resources the first premise of transforming the mentioned natural resources into economic ones is not significantly hindered. According to experts, the current technology has advanced in such a way that there is little to improve in this regard (see Dozolme 2012). The problem lies rather in the second premise: As a result of a decrease of the stock of these resources their strategic importance increases. The idea of local governments concerning their deposited wealth is reflected both in their applied requirements when determining the conditions for the authorization of mining, and by the prices and mode of payment for the rendered mining rights. The agreement or disagreement on this issue often influences the future of deposited wealth being used for the benefit of all. A useful tool that can help to solve this problem is presented in Hašková and Kolář (2012).

In the case of renewable energy sources today the situation is different. Meeting the second premise is widely supported by various incentives and subsidies. Special technologies (small hydro power plants, biofuel boilers, wind turbines, photovoltaic solar panels, etc.) allow transforming the energy potential of these sources into electrical energy, and therefore utilizing it meaningfully. The problem with these sources lies rather in the fact that even though they may limit the undesirable externalities of traditional producers, they can not compete with their economic efficiency. If we place the utmost emphasis on the integration of renewable energy sources with the willingness to cover the potential economic losses through subsidies to the producers of these energy sources, we face the problem of how to minimize these losses by appropriately allocating subsidies and how best to use the given amount of subsidies. The primary aim of this paper is to help to solve this problem as demonstrated in the case of small hydro power plants.

The financial analysis examining the effectiveness of individual producers' projects offers various tools for the suitable solving of this issue (see Brealey, Myers and Marcus 2011). The simplest, and in practice often used criterion is the simple payback period (SPP). However, this criterion works reliably only in the case of the payback period being longer than the lifetime of the project (so that the invested capital will not ever be paid back), and this results in excluding the project from the game. In the opposite case, the shorter simple payback period does not say much about the economic efficiency of the project. A more appropriate tool than the previous one is the internal rate of return of the project (IRR) but it does not say explicitly what amount of subsidy is adequate. That can be ascertained from the budgeted net present value (NPV) of the project.

In the following we build on the requirement of a 7% rate of return on investment in small hydro power plants and we calculate the values of these criteria for three considered projects. From their comparative analysis and from other assumptions we formulate the criterion of the efficient allocation of subsidies. All necessary calculations and tables are taken from the bachelor

thesis of the student Ivo Chládek (see Chládek 2011), in which they are justified in detail and where other relevant information can be found.

### Project SHP<sub>1</sub> (small hydro power plant)

The project deals with the renewal and modernization of the former power station on the river Sázava in the locality of Okrouhlice (see Chládek 2011; Czech energy agency 2006a). The expected lifetime of the project is 30 years; the electric power of the generators is 90 kW. From the average data collected during the previous operation time the following table has been constructed, interpreting the calculation procedure of the expected annual cash flow:

Table 1: The forecast of components of the annual cash flow (in CZK) generated by SHP<sub>1</sub> over 30 years

	Period in years	0	1	2	3–11	12–30
1	Capital investments	1,892,448	2,450,000			
2	Income from sale			490,000	490,000	490,000
3	Operating costs			40,000	40,000	40,000
4	Depreciation of buildings over 30 years			26,495	64,343	64,343
5	Depreciation of technologies over 10 years			134,750	257,250	0
6	Profit before tax (2–3–4–5)			288,755	128,407	385,657
7	Tax rate 24% (line number 6 × 0.24)			69,301	30,818	92,558
8	Net profit (6–7)			219,454	97,589	293,099
9	Cash flow from operation (4+5+8)			380,699	419,182	357,442
10	Net cash flow (9–1)	-1,892,448	-2,450,000	380,699	419,182	357,442

The amount of 1,892,448 CZK represents the construction expenditures; the amount of 2,450,000 CZK the technology expenditures. The project financing was carried out from investors' resources and from a ČEA subsidy (Czech Energy Agency) that amounted to 1.2 million CZK.

### Estimation of simple payback period (SPP) of investment in SHP<sub>1</sub>

On the website [www.eis.cz/dokumenty/822\\_3\\_0\\_12003-12-04\\_15-20-25.doc](http://www.eis.cz/dokumenty/822_3_0_12003-12-04_15-20-25.doc) we can read that on the basis of some unspecified economic evaluation in the case of SHP<sub>1</sub> the simple payback period is 6.41 years  $((4,342,448 - 1,200,000) / 490,000 = 6.413)$ . This approach to calculations does not reflect reality, which reveals that on the river Sázava the payback periods of SHP lie in the range of between 15 to 20 years of operation. Therefore, the above stated value of the return rate can not be taken into account.

When estimating the real simple payback period (SPP) we proceed from the following condition

$$\sum_{i=2}^X CF_i \leq 4,342,448 < \sum_{i=2}^X CF_i + CF_{X+1} \quad (1)$$

in which  $4,342,448 = 1,892,448 + 2,450,000$  and  $CF_i$  is the amount shown in the last line of Table 1 in the  $i$ -th period. Hence  $X = 11$ . Because of that, it applies for the simple payback period (SPP):

$$SPP = X - 1 + (4,342,448 - \sum_{i=2}^X CF_i) / CF_{X+1} \quad (2)$$

from which we get

$$SPP = 11 - 1 + (4,342,448 - 4,153,337) / 357,442 = 10.53 \text{ years}$$

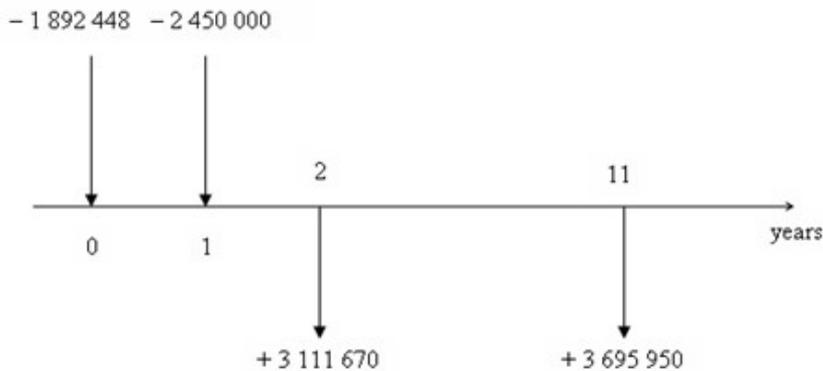
As the simple payback period (ten and a half years) is much shorter than the expected lifetime of the project (thirty years), there is a good chance for the return of the invested capital and a good chance that the project could be acceptable (economically efficient). However, it is necessary to determine with the calculation of its NPV (net present value) whether it promises the desired average of an annual return rate of 7% for every crown spent.

### Estimation of NPV and IRR of the SHP<sub>1</sub> project

The last line of Table 1 shows that in the period of 3 to 11 years the estimated incomes generated by the project have the character of a nine-year annuity with annuity payments in the amount of 419,182 CZK. They are followed by the period of the nineteenth annuity (12 to 30 years), with annuity payments in the amount of 357,442 CZK. For the purpose of calculating NPV it is convenient to represent the first annuity with its equivalent payment in the amount of  $FV(2) = 419,182 \times 6.515 = 2,730,971$  in period 2 and the second annuity with the equivalent payment in the amount of  $FV(11) = 357,442 \times 10.34 = 3,695,950$  in period 11. The constants  $6.515 = (1 - 1 / 1.07^9) / 0.07$  or respectively  $10.34 = (1 - 1 / 1.07^{19}) / 0.07$  are nine or respectively nineteen years annuity factors at a discount rate of 7%.

Thus, we obtain the following scheme of the modified time structure of the SHP<sub>1</sub> project cash flow:

Figure 1: The scheme of the modified time structure of SHP<sub>1</sub> project cash flow



We obtain the modified incomes  $CF_2 = CF_2 + FV(2) = 380,699 + 2,730,971 = 3,111,670$  in period 2 that was formed by increasing the original payment  $CF_2$  by the  $FV(2)$  nine year annuity and  $CF_{11} = FV(11)$ . With the required yield of 7% for NPV of this flow we get (and thus of the project SHP<sub>1</sub>):

$$\begin{aligned}
 NPV &= -1,892,448 - 2,450,000/1.07 + 3,111,670/1.07^2 + \\
 &+ 3,695,950/1.07^{11} = -1,892,448 - 2,228,720 + \\
 &+ 2,717,853 + 1,755,576 = +291,261 \text{ CZK}
 \end{aligned}$$

Due to the fact that NPV of the project is positive, IRR has to be greater than the discount rate of 7%. For a more accurate estimation we solve the equation

$$\sum_{i=0}^{30} CF_i / (1 + IRR)^i = 0 \tag{3}$$

In the case of SHP<sub>1</sub> for  $IRR\ 7.96\% < IRR < 8\%$  applies. This implies that even in the event of a necessary overhaul (NO) of equipment in the middle of the project's lifetime the investment yield would not drop below 7% if the future actual costs of the NO did not exceed the amount of 800,000 CZK ( $291,261 \times 1.0715 = 291,261 \times 2.759 = 803,589$ ). As we can see, the investment in SHP<sub>1</sub> is a relatively lucrative business, so the subsidy from ČEA in the amount of 1.2 million CZK was not needed and can be regarded as a not entirely deserved and necessary "gift" to the investor.

### Project SHP<sub>2</sub> (small hydro power plant)

The subject of the second project analysis is the installation of a small hydro power plant in the village Chodouň near Zdice on the river Litavka instead of the former mill (see Chládek 2011; Czech energy agency 2006b). The expected lifetime of the project is 30 years; the maximum electrical power of the generator is 30 kW. From the average data collected during the previous operation

Table 2: The forecast of components of the annual cash flow (in CZK) generated by SHP<sub>2</sub> over 30 years

Period in years	0	1	2	3-11	12	13	14-30
1 Capital investments	860,000	940,000					
2 Income from sale			150,000	150,000	150,000	150,000	150,000
3 Operating costs			33,000	33,000	33,000	33,000	33,000
4 Depreciation of buildings over 30 years			12,040	29,240	29,240	29,240	29,240
5 Depreciation of technologies over 10 years			51,700	98,700	0	0	0
6 Profit before tax (2-3-4-5)			53,260	-10,940	87,760	87,760	87,760
7 Tax rate 24% (line number 6 × 0.24)			12,782	0	0	18,494	21,062
8 Net profit (6-7)			40,478	-10,940	87,760	69,266	66,698
9 Cash flow from operation (4+5+8)			104,218	117,000	117,000	98,506	95,938
10 Net cash flow (9-1)	-860,000	-940,000	104,218	117,000	117,000	98,506	95,938

Table 3: The forecast of components of the annual cash flow (in CZK) generated by SHP<sub>3</sub> over 30 years

Period in years	0	1	2	3-11	12	13-30
1 Capital investments	5,000,000	7,000,000				
2 Income from sale			1,200,000	1,200,000	1,200,000	1,200,000
3 Operating costs			360,000	360,000	360,000	360,000
4 Depreciation of buildings over 30 years			70,000	170,000	170,000	170,000
5 Depreciation of technologies over 10 years			385,000	735,000	0	0
6 Profit before tax (2-3-4-5)			385,000	-65,000	670,000	670,000
7 Tax rate 24% (line number 6×0.24)			92,400	0	20,400	160,800
8 Net profit (6-7)			292,600	-65,000	649,600	509,200
9 Cash flow from operation (4+5+8)			747,600	840,000	819,600	679,200
10 Net cash flow (9-1)	-5,000,000	-7,000,000	747,600	840,000	819,600	679,200

time the table 2 has been constructed, showing the calculation procedure of the expected annual cash flow.

The amount of 860,000 CZK represents the construction expenditures, the amount of 940,000 CZK the technology expenditures including audit. The project was financed by firm resources and from a state subsidy in the amount of 180,000 CZK.

In contrast to Table 1 we see that after the first year of profitable SHP<sub>2</sub> operation the next nine years accumulate an annual loss of 10,940 CZK. Then it generates a profit again, and the accumulated loss in the total amount of  $9 \times 10,940 = 98,460$  CZK is used to reduce a taxable income in future years: In the 11th year of operation (period 12) the 87,760 CZK is applied, by which the firm resets its tax base and pays no tax. With the rest of  $98,460 - 87,760 = 10,700$  CZK it reduces the tax base in period 13 to  $87,760 - 10,700 = 77,060$  CZK, from which it pays tax of  $0.24 \times 77,060 = 18,494$  CZK. In the resulting cash flow (line 10 of Table 2) two annuities can be traced: The first one (ten-year) with an annuity payment of 117,000 CZK starts in period 3 and the second one (seventeen-year) with an annuity payment of 95,938 CZK starts in period 14.

### **Estimation of simple payback period (SPP) of the investment in SHP<sub>2</sub>**

When estimating a simple payback period of the investment in SHP<sub>2</sub> we emerge from the relations (1) and (2) for SHP<sub>1</sub>, where the value of 4,342,448 is replaced by the value of  $1,800,000 = 860,000 + 940,000$  and the  $CF_i$  amounts are taken from the last line of Table 2. From such a modified condition (1) we get  $X = 17$  and from it the following modified equation (2) for SPP applies:

$$SPP = 17 - 1 + (1,800,000 - 1,756,476)/95,938 = 16.45 \text{ years}$$

Since the simple payback period  $SPP = 16.45$  of the project SHP<sub>2</sub> is significantly shorter than its expected lifetime (thirty years), it is meaningful to continue with the calculations of NPV and IRR.

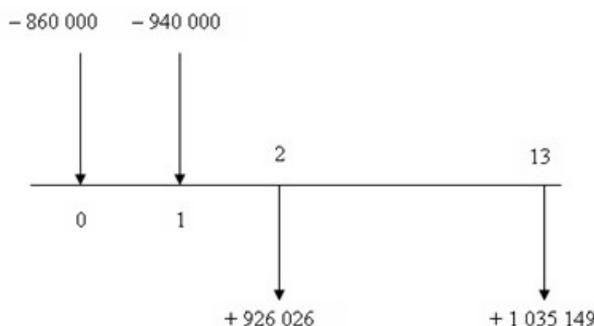
### **The estimation of NPV and IRR of the project SHP<sub>2</sub>**

Analogously as in the case of the project SHP<sub>1</sub> we can use the above mentioned existence of two annuities in the cash flow generated by the project SHP<sub>2</sub> (the last line of Table 2) to simplify the technique of NPV calculation. The first (ten-year) annuity payment can be replaced by its equivalent payment in the amount of  $FV(2) = 7.024 \times 117,000 = 821,808$  in period 2 and the second annuity (seventeen-year) by its equivalent payment in the amount of  $FV(13) = 95,938 \times 9.763 = 936,643$  in period 13. The constants  $7.024 = (1 - 1 / 1.0710) / 0.07$  or respectively  $9.763 = (1 - 1 / 1.0717) / 0.07$  are ten or respectively seventeen-year annuity factors at a discount rate of 7%.

Thus, we obtain the modified incomes  $CF_2 = CF_2 + FV(2) = 104,218 + 821,808 = 926,026$  and  $CF_{13} = CF_{13} + FV(13) = 98,506 + 936,643 = 1,035,149$ . This corresponds to the following scheme of the modified time

structure of the cash flow:

Figure 2: The scheme of the modified time structure of SHP<sub>2</sub> project cash flow



$$\begin{aligned}
 NPV &= -860,000 - 940,000/1.07 + 926,026/1.07^2 + \\
 &+ 1,035,149/1.07^{13} = -860,000 - 878,505 + 808,827 + \\
 &+ 1,035,149 \times 0.415 = -500,091\text{CZK}
 \end{aligned}$$

Because of the fact that NPV of the project is negative, its IRR has to be lower than the discount rate of 7%. IRR's more accurate estimation is derived from the solution of equation (3) for  $CF_i$  of Table 2, which for  $3.84\% < IRR < 4\%$  applies. In order to achieve the required 7% annual rate of return on investment the subsidy needed would be an amount exceeding five hundred thousand CZK. The subsidy of 180,000 CZK does not help much; it only moderates the loss slightly.

### The project SHP<sub>3</sub> (small hydro power plant)

Unlike the previous two already realized projects, in this case we deal with an assessment of a hypothetical project of a variation close to reality of an often occurring investment opportunity specified in more detail in Chládek (2011). The calculation of the budgeted cash flow of the project, in which the maximum electrical power of the generator is 90 kW, is summarized in Table 3.

Similar to SHP<sub>2</sub> the project SHP<sub>3</sub> accumulated after the first year of profitable operation an annual loss for the following nine years due to the adopted depreciation policy; this time in the amount of 65,000 CZK per year. Thereafter it generated a profit, and the accumulated loss in the total amount of  $9 \times 65,000 = 585,000$  CZK was used to reduce a taxable income in the following year. By reducing the tax base to  $670,000 - 585,000 = 85,000$  CZK the firm paid a tax of  $0.24 \times 85,000 = 20,400$  CZK. In the resulting cash flow (line 10 of Table 3) two annuities can be found, of which the first one (nine-year) with an annuity payment of 840,000 CZK starts in period 3. The second one

(eighteen-year) starts in period 13 with an annuity payment of 679,200 CZK.

**Estimation of simple payback period (SPP) of the investment in SHP<sub>3</sub>**

When estimating the simple payback period of the SHP<sub>3</sub> investment we emerge from the relations (1) and (2) for SHP<sub>1</sub>, where the value 4,342,448 is replaced by the value 12,000,000 = 5,000,000 + 7,000,000 and the amounts of CF<sub>i</sub> are taken from the last line of Table 3. From such a modified condition (1) we get X = 15 and from it the ensuing modified equation (2) for SPP then follows:

$$SPP = 15 - 1 + (12,000,000 - 11,844,000)/679,200 = 14.23 \text{ year}$$

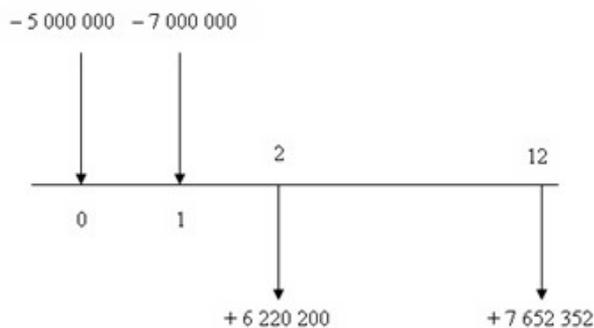
Since the forecasted simple payback period SPP on investment in the project SHP<sub>3</sub>, compared to its estimated operation lifetime, is less than a half, it makes sense to continue with the calculations of NPV and IRR.

**Estimation of NPV and IRR of the SHP<sub>3</sub> project**

Analogously as in the case of previous projects, we can use the above mentioned existence of two annuities in the cash flow that are generated by the project SHP<sub>3</sub> (last line of Table 3) in order to simplify the NPV calculation technique. The first (nine-year) annuity payment can be replaced by its equivalent payment in the amount of FV(2) = 840,000 × 6.515 = 5,472,600 in period 2. The second (eighteen-year) by its equivalent payment of FV(12) = 679,200 × 10.06 = 6,832,752 in period 12. The constants 6.515 or respectively 10.06 are nine or respectively eighteen-year annuity factors at a discount rate of 7%.

Thus, we obtain the modified incomes CF<sub>2</sub> = CF<sub>2</sub> + FV(2) = 747,600 + 5,472,600 = 6,220,200 and CF<sub>12</sub> = CF<sub>12</sub> + FV(12) = 819,600 + 6,832,752 = 7,652,352. This corresponds to the following scheme of the modified time structure of the cash flow:

Figure 3: The scheme of the modified time structure of SHP<sub>3</sub> project cash flow



$$NPV = -5,000,000 - 7,000,000/1.07 + 6,220,200/1.07^2 + \\ +7,652,352/1.07^{12} = -2,711,449 \text{ CZK}$$

Since NPV of the project is negative, IRR has to be lower than the discount rate of 7%. We get a more accurate estimation from a solution of equation (3) for  $CF_i$  from Table 3, which for  $IRR\ 4.45\% < IRR < 4.5\%$  applies. To achieve 7% of annual rate of return on the investment it would be necessary to subsidize the project with an amount of nearly three million CZK.

## Discussion

From the financial analysis of the three small hydro power plant projects SHP<sub>1</sub>, SHP<sub>2</sub> and SHP<sub>3</sub> it unequivocally follows that if these projects should offer to investors the equivalent conditions in terms of the required 7% of average annual appreciation of investment, then the project SHP<sub>1</sub> should not be subsidized at all (the advantage at the starting point ensuring the investor an abnormal income of 291,261 CZK), the project SHP<sub>2</sub> should be subsidized by at least half a million CZK and the SHP<sub>3</sub> project by the amount of close to three million CZK. These amounts were revealed by net present value (NPV) calculations of the projects. NPV criterion, derived from the principle of utility maximization of wealth, is the most convincing and most easily interpretative criterion for the evaluation of investment efficiency. The considered projects are evaluated according to their effectiveness as follows: SHP<sub>1</sub>, SHP<sub>2</sub>, SHP<sub>3</sub>.

Simultaneously, we also assessed the three projects according to the simple payback period (SPP) of investments and, implicitly, according to the internal rate of return (IRR), which was not a problem due to the fact that the cash flows of the projects changed the sign only once. The advantage order according to SPP is: SHP<sub>1</sub> (10.53 years), SHP<sub>3</sub> (14.23 years), and SHP<sub>2</sub> (16.45 years). The sequence of preference according to IRR is: SHP<sub>1</sub> (8%), SHP<sub>3</sub> (4.5%), SHP<sub>2</sub> (4%). We see that the criteria for SPP and IRR give the same order of preference that differs from the NPV criterion.

Can we conclude on the basis of prioritizing SHP<sub>3</sub> over SHP<sub>2</sub> from two of the three used criteria that NPV criterion need not be taken into account? It depends on what we mean by "efficiency". Its standard interpretation says that it is the degree of optimal allocation of resources; the optimal allocation means deploying resources to projects where they generate the greatest benefit. Here the resource is the investor's money and the question is what the benefit should be. If it is the increase of the monetary value of the investor's wealth, then NPV dominates. Otherwise, we would have to justify why it is advantageous for us to pay more than two million CZK for the reduction of SPP for two years or for a shift of half a percentage point on the percentage scale of advantageousness.

Another question is in what way to allocate subsidies, if we want with them to even up the profitability of projects to the required 7% and (according to the current environmental doctrine) to involve to the maximum possible

extent the renewable sources of energy (small hydro power plants) in the game, knowing that the subsidies are a limited resource and not attainable by all. The NPV criterion gives the answer to even this question: It is the pursuit of the maximum increase of the installed capacity from the one thousand CZK spent on the subsidy – **installed capacity in kW / (–NPV in thousand CZK)**. This increase for SHP<sub>2</sub> was 0.06 kW / thousand CZK ( $30 / 500.091 = 0.06$ ), and for SPH<sub>3</sub> it was 0.033 kW / thousand CZK ( $90 / 2711.449 = 0.033$ ). As we can see, it is almost twice as efficient to subsidize SHP<sub>2</sub> than SHP<sub>3</sub>.

### The environmental point of view on small hydro power plants

Hydropower is considered to be the most significant renewable resource for electrical power production in the world. It provides 19% of the planet's electricity (Paish 2002). Small hydro power plants are usually constructed on watercourses with no dam or water reservoir. This energy production is considered to be cost-effective and environmentally friendly as it shows advantages in terms of CO<sub>2</sub>. However, often unknown to the public these eco-projects are likely to generate some undesirable environmental impacts, which are rarely evaluated and calculated within the project. It concerns the local landscape changes and riverine species. The evaluation performed in (Pinho et al. 2007) revealed many technical and methodological deficiencies in a large number of examined eco-projects. The majority of underestimated cases in the pre-calculations were: (1) Reservoirs may prevent the transit of fish, so the natural flow of silt down the river will be discontinued harming ecosystems. (2) It is necessary to clear the trees from large water tanks; otherwise the methane gas produced by decaying wood is as rich in CO<sub>2</sub> emissions in as a fossil-fuel plant with similar output.

A number of studies deal with the occurrences of these problems (Prchalová et al. 2009); however, the financial side of things is being neglected. As a result the evaluation of “green energy” benefits from SHPs cannot be as straightforward as is commonly presented. This is demonstrated in (Li et al. 2014), where the ecological losses of 5 large hydropower projects and 10 small hydropower stations were analyzed and the results were taken into account in the calculation of NPV criterion. The holistic financial analysis covering all relevant standpoints often reveals significant aspects of the eco-projects from the environmental point of view as shown in (Maroušek et al. 2014a, 2014b; Maroušek 2014c).

### Conclusion

The conclusion that emerged from the previous discussion does not only apply to small hydro power plants, but to renewable energy sources in general. If we place the emphasis on the maximum utilization of renewable energy sources together with the fact that we are willing to cover potential economic losses resulting from it by subsidies, then it is the financial analysis of the effectiveness of these projects based on NPV criterion, which shows the right way.

The subsidy policy is then *economically efficient* if and only if:

- Only the projects that would reach the negative NPV without subsidy at the discount rate of the promised (in our case 7%) expected value of the annual return during the lifetime of the project are funded.
- The projects are funded in the amounts of the PV, which equals to  $-NPV$ ; this balances the NPV of the subsidized projects to the desired zero ( $NPV = 0$ ).
- In the case of a limited amount of subsidy funds the grant applicants are satisfied according to the order given by the value of the criterion  $kW / (-NPV)$ .

Aside from evaluating the gains and losses generated by the SHP project it is necessary to express the financial impact of environmental changes and adjust the pre-calculation according to these estimates.

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## **Příspěvek k formulaci ekonomicky efektivní dotační politiky v oblasti malých vodních elektráren**

Příspěvek analyzuje ekonomickou stránku dotační politiky v oblasti malých vodních elektráren. Konfrontuje stávající praxi s teorií a navrhuje ekonomicky efektivnější řešení. Jedná se o první ze série příspěvků věnovaných problematice poskytování dotací producentům energie z obnovitelných zdrojů, k nimž mimo jiné patří tekoucí voda, biopaliva, vítr a sluneční záření. Opírá se o výsledky tří případových studií analýzy ekonomické efektivnosti malých vodních elektráren, řešených přístupem „case-based reasoning“. První dvě studie se týkají již realizovaných a fungujících vodních elektráren na řekách „Sázava“ a „Litavka“ v ČR. Jejich veřejně přístupné parametry a jiná potřebná data lze nalézt na stránkách <http://www.eis.cz>. Třetí analyzovaný projekt je ve stadiu záměru a dosud realizován ani dotován nebyl. Výpočty zde vychází z rozpočtovaných údajů a slouží k demonstraci a ilustraci navrhovaného kritéria ekonomicky efektivní dotační politiky.

**Klíčová slova:** přírodní zdroj, ekonomický zdroj, obnovitelný zdroj, doba prosté návratnosti, NPV, IRR, ekonomická efektivnost, dotační politika

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HAŠKOVÁ, S., I. CHLÁDEK and P. KOLÁŘ. Contribution to the Formulation of Economically Efficient Subsidy Policy in the Area of Small Hydro Power Plants. *Littera Scripta*. 2014, 7(1), 25–38. ISSN 1805-9112.

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# Functioning of the Second Level Management Control in Light of the Declarations Made by the Polish Local Self-Government

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## Abstract

Entities operating in the public finance sector have recently started facing the challenge of implementing management control mechanisms. In order to successfully handle this task, it is not enough just to involve managers and employees of the given organisation, but it is also necessary to foster conditions favourable to improving management processes for public entities. Since management control is a rather new instrument of the public finance system, the need for ongoing monitoring of the progress taking place in the sphere of its implementation in individual institutions is becoming more and more evident. Bearing the foregoing in mind, the authors of the article has attempted to assess the extent of the management control implementation in local self-government bodies by analysing the declarations made by the these institutions pertaining to the management control status for the years 2010–2011.

**Keywords:** management control, public finance, local self-government bodies

## Introduction

New challenges related to how local self-government bodies function, being the consequences of the current market economy order based on competitiveness and entrepreneurship, have particularly grown in importance within recent years. And even though the tasks of local self-government bodies as well as the means to accomplish them change on an ongoing basis, the very nature of self-government, namely the satisfaction of local needs, remains unaltered. However, confronting the limited resources of local self-government bodies with the inhabitants' needs inevitably leads to a conflict, since it is impossible to satisfy the needs of all members of the given local community to the fullest extent (Stiglitz 2004). Therefore the key problem is not the mere purpose

of the self-government's activity, but more and more often the capability to accomplish it efficiently.

The goal of this article is to assess the progress in the management control implementation in local self-government bodies. The information background which has enabled conclusions to be drawn in this respect are the relevant declarations made with regard to the management control status as of the years 2010–2011.

### **Assessment criteria for the extent of the management control implementation in entities operating in the public finance sector**

Management control is still a fairly new instrument of the public finance system, governed by the provisions of the public finance act. Its main function is to enhance the processes of managing public entities from a clearly defined perspective of attaining individual public goals while maintaining specific standards in terms of the way in which tasks are performed (Walczak 2012). The solutions applied in this sphere are primarily assumed to extend the supervision of public expenses and enable maintaining continuity of the tasks being performed (Sławińska-Tomtała 2012; Olejniczak 2012).

In the early 1980s the traditional public administration began to change rapidly (Zawicki 2011) as a result of the accelerating series of global changes in the world. Low effectiveness of public institutions in times of economic and political crisis were placing new pressures on governments but also created new opportunities for governmental transformation (Lynn 2006). Many developed countries (Australia, Canada, New Zealand, UK and USA) started to pick up the pieces and search for new, more effective ways of meeting social needs (Kettl 2000). Interest in public sector reforms gradually spread to Canada, Netherlands and other developing countries of Western Europe (Lubińska 2009; Osborne and Gaebler 1992). As a result the term “New Public Management” (NPM) was coined (Hood 1989). NPM referred to public administration as an important element of civil society networks (in the broader sense), remaining in the interaction with the members (individuals, groups) of civil society (in the narrow sense) through appropriate participatory procedures and close collaboration with stakeholders. New public management reforms were based on some basic assumptions such as: (i) promoting competition in the area of service delivery, (ii) measuring the activity and focus on results and financial results rather than on inputs, (iii) mission oriented aims and management instead of activities only based on compliance with rules and regulations, (iv) preventing problems by anticipating them. The new paradigm emphasized the fact that the administration is filling instructions, while management is achieving results (Hughes 1994). According to NPM entrepreneurial spirit should transform the public sector and thus improve the efficiency of actions taken by public institutions. One of the instruments that should be used to improve the quality of public management is management control.

In accordance with article 68 of the act of 27<sup>th</sup> August 2009 on public finance in Poland, the management control over the entities operating in the

public finance sector comprises a set of actions undertaken in order to ensure that the given objective and tasks are completed in a fully legal, efficient, economical and punctual manner. Moreover, the regulations applicable in this respect stress that the said objectives and tasks should be performed:

1. in compliance with the law,
2. efficiently (by ensuring the best possible correlation between expenses and outcomes),
3. economically (by ensuring the lowest attainable cost for the objectives and tasks to be performed assuming appropriate quality),
4. punctually (by completing the objectives and tasks in due time, with no expenditure increase or quality decline).

The obligation to implement the means of management control has been imposed on all entities operating in the public finance sector, regardless of the subject of their activity, their legal form or the amount of funds spent. According to the statutory definition, management control is every action of an entity, and all the principles applicable therein, which serve the purpose of ensuring completion of objectives and tasks. Functioning of adequate, successful and efficient management control is included in the scope of duties of:

- a minister, in the administrative departments managed by the former,
- a commune head, a commune and town mayor, a chairman of the local administrative unit's managing body,
- a manager of the given entity.

Due to the specificity of the national territorial division of Poland, the management control function is performed on two levels:

- a) on the level of organisational units established to perform tasks (level I),
- b) on the level of local self-government bodies considered as an entirety (level II).

Management control sanctioned by the public finance act of 2009 substituted the formerly applied notion of financial control which functioned under the provisions of the previous public finance act of 30<sup>th</sup> June 2005. This, however, did not relieve the relevant entities from the obligation to implement financial control, since it should be stressed that the notion of management control also comprises financial aspects of the functioning and control of the given entity. Hence management control may be analysed in two dimensions. In the institutional dimension, performance of management control is required at each stage of management, starting from the top tier of the commune head, district governor or province marshal, through medium-level managers, independent employees, down to ordinary officers who also participate in the management

control scheme by means of self-control. The second dimension of control is built of all sorts of standards, procedures, policies and action plans implemented by an entity as well as all the principles defining the scope of activity of institutional units.

In terms of the management control implementation, the standards of management control published by the Ministry of Finance, establishing the basic requirements of its execution, are of particular importance, since their purpose is to develop a coherent and uniform management control model conforming with internationally recognised solutions applied in this sphere, entailing the specificity of and the conditions under which the given implementing unit operates (Gumińska et al. 2012). The aforementioned standards have been collated under five groups to form a selection of guidelines providing managers of public finance entities with general assumptions they should rely on while creating a management control system. The management control standards as well as their constituents and characteristics have been described in detail in the relevant Announcement of the Minister of Finance (Announcement no. 23 of the Minister of Finance of 16<sup>th</sup> December 2009 on management control standards for the public finance sector (Official Gazette of the Republic of Poland Monitor Polski, no. 15, item 84).

- a) 1<sup>st</sup> Group of standards (A) – internal environment.
- b) 2<sup>nd</sup> Group of standards (B) – Objectives and risk management.
- c) 3<sup>rd</sup> Group of standards (C) – Control mechanisms.
- d) 4<sup>th</sup> Group of standards (D) – Information and communication.
- e) 5<sup>th</sup> Group of standards (E) – Monitoring and assessment.

It should be stressed that, while providing the standards to form the grounds for the management control performance, the legislator has not defined a selection of actions necessary to implement the former under specific conditions. It is therefore evident that these standards are essentially of general nature, and their function is to establish common principles to be applied in all entities operating in the public finance sector (Puchacz 2010). Consequently, no detailed instruments dedicated to the management control implementation have emerged on the level of local self-government bodies. Most authors commenting upon this subject share the opinion that the lack of such a predefined selection should not preclude the implementation of management control, and in this respect, individual entities should follow the principles of legality, punctuality, economic soundness and efficiency (Filipiak 2012). However, by no means does it change the fact that under the current conditions, individual entities implement selected procedures which limits the possibility to analyse the activities undertaken in the scope of the management control implementation. And since management control is a rather new instrument of the public finance system, hence the need for ongoing monitoring of the progress taking place in the sphere of its implementation in individual institutions, which is becoming more and more evident and which may be used to answer the following questions:

- a) What efforts are undertaken in the scope of implementation of the management control mechanisms?
- b) What kinds of information are used to provide the grounds for verification of the control actions performed?
- c) What are the barriers encountered in terms of the implementation of control procedures?

The problems discussed provide a framework of research subjects, an analysis of which requires information grounds to be defined, so that their verification is possible. Under the current conditions, they mainly result from the documents drawn up according to statutory requirements. By the end of November each year, local self-government bodies are obliged to develop a plan of controlling operations assumed for the following year. What the said plan should entail in particular is the determination of objectives assigned to individual control tasks along with indication of sub-tasks whose purpose is to accomplish the relevant objectives as well as measures enabling the extent to which the given objective has been completed to be established. Also, by the end of April each year, every duly authorised entity must draw up a progress report on the control activity plan execution and submit declarations on the management control status for the preceding year.

The latter is a document of particular importance, as it provides grounds for a statement of the management control status for the given entity. It is an intentional and relevant document which enables the control to be handled adequately to the needs as well as in a reliable and systemic manner (Announcement of the Minister of Finance of 2009). In the Regulation of 2<sup>nd</sup> December 2010 (source: Official Journal of Laws, no. 238, item 1581 of 2010), the Minister of Finance established a template for a declaration of the management control status which, therefore, became the basic form of documentation of the works undertaken in the scope of management control. As regards the foregoing, it constitutes the fundamental, although indirect information basis enabling conclusions to be formulated on the progress of the implementation in individual entities.

### **Assessment of the management control implementation extent in local self-government bodies – results of the studies conducted**

In order to analyse the extent to which management control is applied, studies on the second management control level were conducted. The complex nature of the phenomena presented within the thematic scope of the project, required a diversified set of techniques and research methods, enabling collection of data referring to self-government units, in particular relating to objectives and principles of their operation. The implementation of the indicated research approach required conducting comprehensive research including

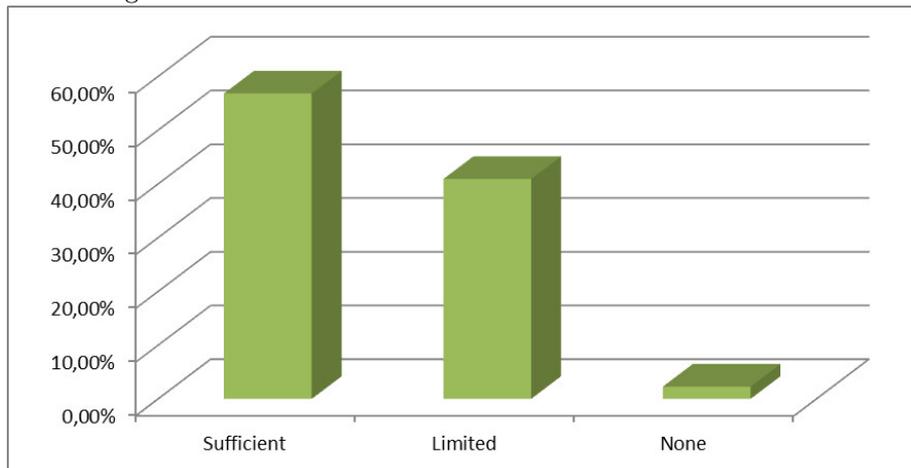
- a) desk research (including analysis of domestic and international literature devoted to management control in the public sector that has been pub-

lished up to date and analysis of self-government units operation within economic, social, political, legal-financial and technological aspects).

- b) empirical research (a survey addressed to the self-government units in Poland aimed at obtaining data describing the extent of management control implementation in the public sector).

The main sources of information used in the studies were the declarations made in accordance with article 70, section 3 of the public finance act of 27<sup>th</sup> August 2009 (Official Journal of Laws, no. 157, item 1240, as amended) on the management control status in the years 2010–2011. The studies comprised 44 entities. Due to a large size of the population studied in the relevant entities, the sample was chosen by a simple random selection (Babbie 2004). The results obtained have been illustrated below.

Figure 1. Extent of adequate, successful and efficient management control functioning

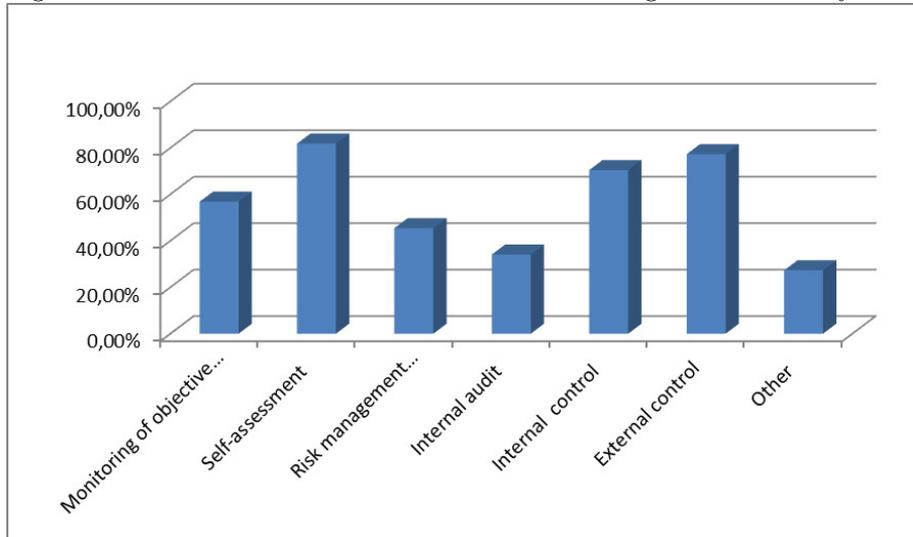


Source: Author's own study based on the study results obtained

The analysis of the information provided in the declarations on the management control status implies that a decided majority of the entities concerned (i.e. 57%) declared that the management control was functioning at least to a limited extent. The only example of an entity where the management control scheme was not functioning was the assessment conducted by the Municipal Office of Unisław for the year 2010. However, it should be stressed that the assessment of the extent to which the system functions is of declarative nature, and to a considerable degree, it is based on a subjective impression of the manager making the declaration. For neither the forms being submitted, nor the literature of the subject and the current practice of management control application have provided any measurable criteria; the compliance with which would entitle the given entity manager to declare to what extent the management control functions is sufficient or limited. Therefore, bearing the

discretionary nature of the above declarations in mind, what seems to be more important is the information provided in the declarations pertaining to individual aspects of management control.

Figure 2. Sources of information used under the management control system



Source: Author's own study based on the study results obtained

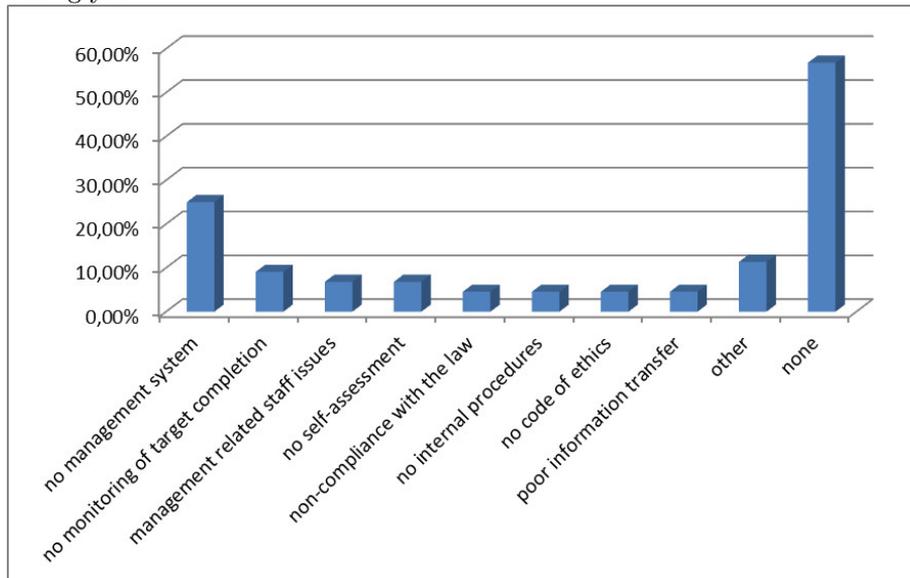
The main information source taken into consideration while assessing the extent to which the management control functions was the self-assessment (more than 80% of responses). This observation is a reference to the aforementioned largely discretionary nature of the assessment provided in the form, since self-assessment, which should essentially rely on pre-established management control standards for the public finance sector in its current form, does not provide any explicit indicators enabling the process studied to be monitored in the entities of the second level management control. Another significant fact in this respect is also the lesser importance attached to monitoring of the objective and task completion as well as the risk management process, being the information areas which, due to their nature, constitute the essential conditions for the effectiveness of actions taken.

To a limited extent, the entities studied also highlighted the application of other information sources than those proposed in the form (only 27% of responses). However, there are some among them which are worth stressing, as they may provide a significant informative support for the management control process when following a good model adopted in other entities. These are separate declarations made by managers and directors of organisational units, ongoing supervision of subordinate units or a report from a review of surveys containing information obtained from inhabitants.

The statement provided in the declaration with regard to the status of management control in the given entity automatically requires indication of barriers

and obstacles encountered in the implementation process by individual entities.

Figure 3. Reservations to the functioning of management control in the preceding year



Source: Author's own study based on the study results obtained

The most common reservation among those stated in the declarations pertaining to the way management control functions is the lack of risk management system implemented in the entity (25% of those surveyed). The lack of appropriate solutions in this respect makes it difficult to prepare task performance procedures and suitable control mechanisms enabling the expected efficiency of management control to be attained. The process of risk identification and analysis being advanced and documented, and the resulting risk register established on such a basis were only declared in one entity studied, i.e. the Municipal Office of Godów.

However, what is striking is the fact that the entities studied usually did not mention any reservations as to the current state of matters, which may be either evidence their actual absence, or prove low awareness of the managing personnel with regard to the problems related to implementation of the management control system.

A significant signal explaining this issue is the set of actions mentioned as those undertaken in the preceding year in order to improve the functioning of management control. In as many as 90% of the entities studied, no such activity aimed at implementation of suitable procedures was specified. This fact clearly contradicts the reservations previously declared with regard to the extent to which the management control functions. According to the information provided in Table 1, such doubts were mentioned in the declarations submitted by representatives of nearly 42% of the entities studied. Therefore, the lacking

efforts in response to the lack of confidence in the adequacy, successfulness and efficiency of the management control in place clearly imply that the awareness of individual entities to the need for introduction of changes should be assessed negatively. Among the rare examples of the actions actually declared as undertaken, the respondents mentioned documenting the risk identification and analysis process, maintaining the risk register, introduction of the CAF self-assessment model and ordinances adopted with regard to implementation of the management control principles. One should also mention some other efforts described, namely those which consisted in making procedures and standards more detailed with reference to the actual needs of the given entity, which may be interpreted as yet another proof of the general nature of the statutory regulations and guidelines imposed by central authorities.

The limited scope of the efforts undertaken implied the need for enquiring about the scope of actions planned by individual entities for the near future, aimed at improvement of the management control functioning. In this respect, most of those surveyed mentioned two groups of actions aimed at:

- a) Information transfer improvement within the organisation (e.g. rearrangement of the organisational structure, regular meetings with administration officers and the managing personnel in order to monitor and identify issues and seek solutions);
- b) Personnel quality improvement (e.g. employee training, self-assessment);
- c) Enhancement of the risk management system (documenting the risk identification and analysis process, determination of the number and types of risks encountered at the entity, defining ways to handle the risk).

However, it is striking that, at the same time, nearly 41% of the entities studied declared no need for any new actions aimed at improving management control.

## Conclusions

Three years after the new public finance act was enacted, management control still seems to be one of the most poorly explored obligations imposed on self-governmental institutions. In the current organisational and legal format, management control is an open selection of permissible solutions, promoting experimentation with tools and procedures. Due to the lack of explicit and transparent interpretation of what management control is and what it should become, functioning next to good practices and well-proven solutions, there are many distortions emerging, making its basic sense obscure.

The conclusions drawn in the article prove that:

- a) there are no objective criteria enabling assessment of the progress in the management control implementation,

- b) the statement of the extent to which management control functions, as provided in the declarations, is largely of declarative nature, as it is based on subjective impressions of the person drawing up the declaration,
- c) the awareness of the management control system specificity and the need for the expected changes to take place among the managing personnel is low.

From the perspective of both theoreticians and practitioners, it means an ongoing challenge of seeking an answer to the questions about the best possible way to satisfy the relevant requirements and to conform with the principles of management control, and about the available instruments to be used for those purposes. The general nature of the management control standards being formulated is not making it any easier for the implementation of specific solutions applied to conform with the principles adopted. The implementation of management control under the framework of public finance reform is but one of the signs of changes which may be jointly referred to as a transformation from the culture of following the law towards the culture of pursuing results.

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KOPYŚCIAŃSKI, T. and J. IGNACY. Functioning of the Second Level Management Control in Light of the Declarations Made by the Polish Local Self-Government. *Littera Scripta*. 2014, **7**(1), 39–49. ISSN 1805-9112.

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# Influences of Global Changes to Evolution of Automotive Business

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## Abstract

This paper focused on the analysis of global turbulences affecting the worldwide automotive business. The article looks for the answers to how new social and technological trends will change the car industry value chain. These global trends include social media, new mobility solutions and provided services, the transition to renewable energy and many additional factors. The subject of the article deals with the different driving forces to development of the automotive industry. The introductory part of this paper describes selected trends that change the automotive business environment from the global point of view. The next part characterizes the description of key influences that are identified within the framework of analysis of the published studies about the acceleration of business in automotive sector.

**Keywords:** management automotive business trends, global changes, markets evolution

## Introduction

Globally, the automotive industry has recovered from the economic crisis. For more than 125 years this sector has played a key role in economic development and human progress. The car has shaped not only the global economy but also how billions of people live. The modern passenger car is a triumph of technology. New product concepts, new segments and growing environmental sustainability also lead to increased complexity. On the other side stagnation in Europe, globalization of sourcing and production, the regulatory demand for new environmentally-friendly propulsion engines or connecting vehicles to multi-modal mobility systems – that's just a few of the stimuli fundamentally changing the automotive industry today. New conditions are providing new opportunities for the automotive industry.

Analysis processing in this article is based particularly on identified trends of the automotive business presented in sector research studies. These challenges will shape the car industry into the future (KPMG 2014):

- Customers: the top priority for today's car buyers is a longer lasting vehicle (enhance vehicle lifespan) with low gasoline consumption (fuel efficiency) and active safety systems
  - 47 % of respondents consider use of alternative fuel technologies as critical to consumers' purchase decisions (interestingly, that down from 70 % in 2009)
  - 54 % believe under-25-year-olds do not wish to own a car; 46 percent say the same is true for over-50s.
- Globalisation: the emerging nations offer the best hope for expansion, as many traditional automotive markets continue to decline
  - 61 % forecast vehicle production in Europe to rationalize and move to emerging markets
  - 74 % of suppliers are beginning investment for new plants.
- Technologies: technology leadership is key to survival for automakers
  - connected car solutions are gaining importance year-on-year
  - 76 % believe that ICE (traditional internal combustion engine) down-sizing is the major focus for the automotive industry
  - plug-in hybrids are forecast to be the leading e-car
  - 69 % consider fuel cell mobility critical for future growth
  - will be used more platform sharing and more modular systems.
- Markets: mature markets are saturated, while emerging markets are rising in importance
  - 44 % are confident that China will export 2 million vehicles by 2016; 37 % predict India to export 1 million by 2016
  - 71 % expect online dealerships to be important and 63 % view multi-brand dealerships as a successful model.

Despite a recent recovery, the global automotive industry is bound to face uncertainty in the coming years.

### **The driving forces to the progress of the automotive sector**

Published reports (cited as references) confirm that the rising economic power of the emerging markets remains the overriding force for growth over the next decade. Markets and production are increasingly shifting to Asia. China has become the largest automobile nation in the world and this will lead to a gradual change in some of the key determinants of the industry (such as its impact on the profit and loss statements of many car manufacturers). In light of increasing urbanization around the globe (and related emission and congestion problems), the electrification of the powertrain is regarded as an attractive solution, and

China sees it as an opportunity to “overtake” established manufacturers in Europe, Japan and the US (Mohr 2013). The Chinese government is strongly supportive of electric cars as part of its longer-term plan to lower pollution in its fast-expanding cities, and reduce dependence upon fossil fuels. The phenomenal expansion of cities in China is putting pressure on the infrastructure and calls for radical solutions – urban vehicle design. One major growth opportunity is in smaller vehicles (subcompacts, microcars, and superminis) (KPMG 2014).

Manufacturers from China benefit from lower labor costs. Chinese players have massively increased their production capabilities. On other hand, Chinese manufacturers need to learn from their current limitations (namely poor quality, massive strengthening of R&D activities, missing branding etc.) (Semcon 2013).

Several key trends affecting automotive business presents tab. 1:

Tab.1: Global influences to adaptation of the automotive industry progress

KEY TREND	SPECIFICATION	
<b>OEMs</b>	<i>Global localization, Additional price pressure</i>	
<b>Competition</b>	<i>Emerging markets investors and suppliers, Selective consolidation</i>	
<b>Legislation</b>	<i>Connected vehicles, Further pressure to reduce carbon emissions, Zero casualties</i>	
<b>Emerging markets</b>	<i>Factor markets</i>	<i>Factor cost inflation, Oil price increase, Availability of skilled workforce, Rising energy costs</i>
	<i>Capital markets</i>	<i>Volatility of equity capital markets, Investor view of automotive industry</i>
<b>Standardization</b>	<i>Increasing use of platforms and standardization of modules</i>	
<b>Ice optimization</b>	<i>Downsizing and optimization of the internal combustion engine</i>	
<b>Fuel-cell e-mobility</b>	<i>Alternative powertrains</i>	
<b>European production</b>	<i>Rationalization of production in Europe and shifting of production to emerging markets</i>	
<b>Battery e-mobility</b>	<i>Increasing the efficiency and performance of batteries</i>	
<b>Finance and leasing</b>	<i>OEM captive financing and leasing</i>	
<b>Urban vehicle</b>	<i>Innovative urban vehicle design concepts</i>	
<b>Connectivity</b>	<i>Connected car technologies, car-to-x communication, digitalization</i>	
<b>Mobility</b>	<i>Mobility as-a-service, mobility solutions</i>	
<b>Self driving cars</b>	<i>Autonomous cars</i>	

Source: author’s adaptation according to KPMG and Roland Berger studies

As the industry becomes more global, automakers are striving to use flexible, modular platforms, to adapt to changing customer preferences. The next most critical global trend is the growing use of platforms and standardization of modules (Roland Berger 2013b). Well into the 1990s, major brands would build four or five different models off a single platform. But car buyers worldwide continue to be more and more demanding. Most automakers respond to this demand with an increasing number of derivatives subject to mark-ups compared with standard models. A modular approach can bring significant process

savings, enabling OEMs (Original Equipment Manufacturer) to produce larger volumes on common platforms. The 10 major OEMs will concentrate mass production across a few, core platforms (Royal Academy of Engineering 2013).

All leading car manufacturers are currently working on driver support technology (systems that warn the driver when they are leaving a lane, slow or even stop the car when an obstacle is identified or park the car automatically, for example), and some companies adopt a more radical approach that places driving in the hands of an on-board and networked computer. Vehicles are becoming ever more dependent upon software. The self-driving car on public roads becomes a real possibility in the future. The success of autonomous cars could change the auto insurance industry, for example (Oliver Wyman 2013).

The emergence of “applets” in smartphones and tablets has changed expectations about usability and the customization of the user experience among consumers aged 30 and under. The introduction of multimedia interfaces in cars marked a first step in response to “appletization” trend (Mohr et al. 2013).

The value of automotive electronics is rising; Internet connections and cloud services are becoming the norm, even in cars. Linking up cars with the Internet (“infomobility”) for car-to-infrastructure communication and ICT certainly offer enormous potential. Delivering services through the car – Internet radio, smartphone capabilities, information/entertainment services, driver-assistance apps, tourism information, and the like – is a promising area for future profits and differentiation. This current trend allows players from other industries to enter the market with innovative business ideas – especially companies from the IT and communications sector (Kleimann 2013).

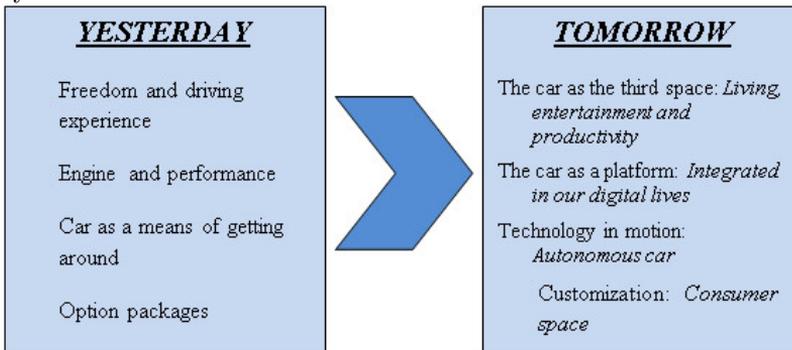
The data required for customized offers is continuously improving. For instance, telematics can automatically notify the manufacturer to send a message directly to a car or smartphone, reminding the owners that their vehicle is due for an oil change and recommend the preferred dealer and special products or service packages at the same time (Roland Berger 2013a). The latter makes it possible to provide tailored offerings via location-based services (geo-marketing). OEMs can provide wireless software updates that continuously create an added value for the customer during the complete car ownership cycle strengthening the bond with the brand. In the future, telematics will also be the basis for predictive maintenance, where the driver is automatically warned ahead of a severe failure. This service can include recommendations how to mitigate the problem with the preferred dealership or in urgent cases the dealer close by, which provides a unique opportunity to avoid a negative product and brand experience (Kleimann 2013).

The web is one of the most important contact points between OEMs and their clients. The Internet will play a greater role in providing customer information and dealer selling techniques (Roland Berger 2013d). New technologies have taken the customer much closer to a buying decision point before visiting the retailer. In the past, the only way to draw up a shortlist was to collect catalogues by visiting retailers. Today, via the Internet, the customer has often made product choices before entering the showroom. With car configurators, customers can specify their vehicles and have a good knowledge of

the list price. Customers are doing more and more of their pre-purchase research online. Now the buyer comes with very precise questions based on a lot of insider information (blogs) (IESE 2012). The core idea is closer direct engagement between vehicle manufacturers and end customers using sophisticated user-friendly technologies. Ongoing OEM/customer interaction would, however, quickly produce results that benefit not only production planning and forecasting, but also the vehicle manufacturers' brands and the development of the kind of vehicle technologies and features that customers want. Thanks to this direct contact, vehicle manufacturers too will be stimulated to drive greater synchronization throughout the business, particularly regarding inventories (Mohr et al. 2013).

The attributes of the traditional car will change, as show fig. 1.

Fig. 1: The most important changes affecting vehicles to future autonomous systems



Source: author's adaptation according to KPMG study (KPMG 2014)

The future of the automotive industry lies in aftersales. The growing number of cars on the road coupled with their higher average age confirms the importance of the aftersales business. The aftersales business is very profitable, e.g. aftersales services generated approximately EUR 30 billion in 2012 in Germany alone (Kleimann et al. 2013). This profitability is attracting a growing number of market players: manufacturers, suppliers, parts wholesalers, authorized and independent repair shops, repair shop chains, insurance companies, automotive banks, mobility services providers and Internet platforms. The aftersales player that best knows its potential customers can put together optimal product packages and accurately design its communication. Micro-marketing with a service offering tailored to each individual customer would be the ideal solution. The first step on this path is an in-depth understanding of customer needs, achieved through detailed segmentation. Customer service is of critical importance for the overall brand experience and driver satisfaction. Post-purchase there is a host of crucial customer touch points, and this is where manufacturers earn the loyalty of their customers. This is when customers decide to return to the same brand for their next car – or not (Kleimann et al. 2013).

The factor most likely to influence consumers' purchase decisions is environmental friendliness – demand greener vehicles (IESE 2012). The environmental issues are increasing in importance for consumers and legislators, press on automotive manufacturers to reduce emissions from their products. As a result, the traditional powertrain is being modified and new engines are being introduced (that pair high performance with lower emissions) and the electrification of the powertrain is progressing at the same time. OEMs will have to develop alternative powertrain technologies for lower-emission vehicles and this will require significant investment (Royal Academy of Engineering 2013).

While alternative new powertrains will even speed up the pace of change, young urban consumers are challenging the very concept of car ownership (a trend calling demotorization). They call for new mobility services such as carsharing and carpooling, which are already experiencing rapid growth (Semcon 2013).

Market studies (Roland Berger 2013d; KPMG 2014) show that the desirability of cars has fallen significantly among younger generations. The so-called 'millennial' generation of young adults appears less interested in traditional purchases (such as houses and cars), and the challenge for the main auto brands is to come up with a new way to meet their needs. While most young adults in the second millennium in their twenties aspired to owning a car, today's young people prefer car sharing (in all its forms) to having "their" car. This has significant implications for the whole automotive value chain, as presented fig. 2 (Roland Berger 2013c). Carsharing and taking a new look at personal mobility are two areas that have come in for special attention. The unique person-to-person (P2P) car sharing business model is the concept based on moving away from traditional car sharing logic to one in which infrastructure needs are met by the vehicle manufacturers and dealers. In this model, vehicle owners who only use their cars some of the time would be able to sign up to a program affording them a preferential initial purchase price plus the opportunity to rent the car out within the OEM's P2P system during periods of non-usage (Roland Berger 2013c).

Fig. 2: The impacts of car sharing strategy to players in automotive



Source: author's adaptation according to Roland Berger study (2013c)

A number of global trends are shaping the automotive industry. All these factors, mentioned in the article, add to the uncertainty facing car business in the first half of the 21<sup>st</sup> century. Results of the change automotive business environment analysis can be summarized in short (Mohr 2013):

- Consumer demands and new regulations will heavily influence the development of auto industry.
- The difficult market has already impacted OEMs margins.
- Alliances of OEMs and players from various sectors are an unavoidable answer to the current challenges in the automotive sector.
- Mobility solutions are increasing in importance (added new value in the passenger transportation of tomorrow).
- All major OEMs have plans for significant expansion in BRIC (Brazil, Russia, India, China) markets.

This analysis offers a perspective on where the automotive industry is headed. It is based on many published in-depth research studies.

## **Conclusion**

Drivers for change and technology development in the automotive industry are in many cases subsets of much wider issues that affect not only the automotive industry but also other activities and businesses. These broad issues include health and safety, environmental concerns and pollution control, climate change, and the potential or actual scarcity of resources. The degree to which one or other of these issues takes priority varies over time.

Many of the changes that will demand innovation in terms of the vehicles that we use, however, are to do with lifestyle choices and personal convenience. Issues such as congested roads, inner cities with limited parking spaces and the sheer cost of running your own car are social factors that are likely to have a significant bearing on future vehicle development. Potentially, automotive industry customers of the future will be buying mobility rather than a car as such: the vehicle may be just one of several options to get from A to B, and may not be the most flexible of those options.

At the same time, the technology revolution of the Internet and mobile devices has also had an impact on automotive sector.

Automotive companies are adapting to a fast-changing competitive landscape. In this article the most important impulses of progress in automotive for the following years was presented. The trends listed above are trends that will affect the whole automotive industry, including distribution and sales.

## **Acknowledgement**

This contribution is the result of the project “VEGA 1/0879/13: Agile, to market adaptable business systems with highly flexible structure in enterprise”

– supported by the scientific grant agency of the Ministry of Education of the Slovak Republic (ME SR) and of Slovak Academy of Sciences (SAS).

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## Vlivy globálních změn na rozvoj automobilového odvětví

Příspěvek je věnován popisu problematiky budoucího vývoje automobilového průmyslu. Je zaměřen na analýzu některých akceleračních vlivů a globálních turbulencí na automobilový sektor. Článek specifikuje odpovědi na otázku, jak nové sociální a technologické trendy mění hodnotový řetězec pro automobilové odvětví. Z globálních trendů jsou za hlavní hnací síly považována sociální média, nové koncepce mobility a řešení poskytovaných služeb, přechod na obnovitelné zdroje energie a mnoho dalších faktorů. Nosným tématem článku je analýza podnětů pro budoucí směřování automobilového průmyslu. V úvodní části jsou popsány vybrané trendy, které z globálního hlediska zásadně mění automobilové podnikatelské aktivity. Následně další část příspěvku obsahuje charakteristiku hlavních vlivů, které byly identifikovány na základě rešeršního studia publikovaných zpráv od renomovaných organizací o predikcích rozvoje automobilového průmyslu.

**Klíčová slova:** automobilový průmysl, trendy, globální změny, vývoj trhů

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LEŠKOVÁ, A. and D. SABADKA. Influences of Global Changes to Evolution of Automotive Business. *Littera Scripta*. 2014, 7(1), 50–59. ISSN 1805-9112.

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