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Evaluation of the development of the manufacturing industry in the V4 countries

Martina Borovcová, Dagmar Richtarová [1]

Abstract

The aim of the article is to analyze, compare and evaluate the situation and development in the selected sector of the economy in the V4 countries for the period 2008–2018. The chosen sector is the manufacturing industry. The indicators used to compare the manufacturing industry in the V4 countries are value added share of production, employment share in total economy, investment intensity based on value added, value added, gross operating surplus, labour productivity per employee. Their values for the observed period are obtained from the OECD database. Subsequently, the manufacturing industry in the V4 countries is evaluated based on the selected indicators using multi-criteria analysis methods. The article applies, and previously described, the Scoring method, respectively a modification of this method, the Method of allocating 100 point and the Weighted Sum Approach method. The obtained results reveal the final assessment of the manufacturing industry in the V4 countries during the analyzed period.

Key words

Manufacturing industry, V4 countries, indicators, Scoring method, Weighted Sum Approach method

JEL Classification: C02, C4, G3, G11

1. Introduction

The article is focused on the evaluation of the development of the selected sector in the V4 countries. The analyzed sector is the manufacturing industry. The manufacturing industry is one of the main sources of the gross domestic product. It consists of sectors that are very different in character. Each sector has its own code, and according to the OECD database, manufacturing is divided into 24 sectors. These are sectors: 10 Food products, 11 Beverages, 12 Tobacco products, 13 Textiles, 14 Wearing apparel, 15 Leather and related products, 16 Wood, products of wood and cork, except furniture, 17 Paper and paper products, 18 Printing and reproduction of recorded media, 19 Coke and refined petroleum, 20 Chemicals and chemical products, 21 Basic pharmaceutical products and pharmaceutical preparations, 22 Rubber and plastic products, 23 Manufacture of other non-metallic mineral products, 24 Basic metals, 25 Fabricated metal products, except machinery and equipment, 26 Computer, electronic and optical products, 27 Electrical equipment, 28 Machinery and equipment, 29 Motor vehicles, trailers and semi-trailers, 30 Building of ships and boats, 31 Manufacture of furniture and 32 Other manufacturing, 33 Repair and installation of machinery and equipment.

The performance of the economy, industry or companies can be evaluated according to different methods. Accounting, economic and market indicators can be used to evaluate performance, see Dluhošová (2004), Vernimmen (2005). For a more in-depth assessment of

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performance, it is advisable to apply pyramidal decomposition and analysis of deviations. Richtarová, Ptáčková, Borovcová (2020) apply pyramidal decomposition and analysis of deviations for the quantification of factors affecting economic value added in the performance evaluation of the selected industries. However, it is also possible to use modified indicators, e.g. those used in OECD databases. The indicators used for this comparison are the value added share of production, employment share in total economy, investment intensity based on value added, value added, gross operating surplus and labour productivity, employment. All selected indicators are available in the OECD database.

The indicator of the share of value added share to production according to the OECD in real terms can provide an insight into the production structure of economic activities. Conversely, the indicator of the share of employment in the total economy deals with the issue of the structure of employment and shows the share of employed persons (i.e. total employment) in the entire economy for each economic activity. The indicator of investment intensity based on added value is calculated according to the OECD as the ratio of gross fixed capital formation in a certain economic activity to value added in this economic activity, both expressed in real values. The value added is determined as gross value added for a specific industry and represents its contribution to national GDP. Sometimes referred to as GDP by industry. It is not measured directly. It is generally calculated as the difference between production and intermediate inputs. Value added comprises labour costs (compensation of employees), consumption of fixed capital, taxes less subsidies on production and net operating surplus and mixed income. According to the OECD, gross operating surplus corresponds to the gross income that economic activities derive from the use of their own productive assets. It represents the gross return on capital from value-added sharing. It includes income from the production of housing services on own account for owner households. The indicator labour productivity, employment according to the OECD represents the amount of output per unit of input. The output is defined as value added in volumes, while the input measure used is total employment.

The aim of the article is to analyze, compare and evaluate the development and situation of the manufacturing industry of the V4 countries using multi-criteria analysis methods.

The basic principles of multicriteria decision-making will be used to assess the level and development of the manufacturing industry in the V4 countries. They deal with the essence of multi-criteria decision-making and the decision-making process (Fotr, Dědina, Hrůzová, 2010), (Brožová, Houška, Šubrt, 2014), (Ramík 1999), (Raju, Kumar, 2014). Thus, the preference of indicators will be determined first, using the selected method of direct determination of weights, and then the Weighted Sum Approach method, which they describe (Ishizaka, Nemery, 2013), (Doumpos, Zopounidis, 2014).

2. Methodology

In order to fulfill the set goal and perform analysis, evaluation and subsequent comparison of the manufacturing industry of the V4 countries, it is possible to use multi-criteria evaluation methods. First of all, it is necessary to determine the weights of the criteria, ie the indicators for assessing the level of the manufacturing industry. Subsequently, the variants, ie the manufacturing industry of individual country, will be compared with each other so that it is possible to compare and evaluate them.

The method of direct determination of criteria weights is used to determine the weights of criteria. This is a modified Scoring method, a Method of allocating 100 points. The weighted sum method is used to compare variants. These methods are briefly described in the following text.

The modified Scoring method, the Method of allocation 100 point, is based on assigning points to individual criteria based on the decision-maker's preferences. It awards the highest number of points to the primary goal and assigns the number to the rest at its discretion. Subsequently, the difference between the main and all secondary targets is determined. Then we only start from the knowledge of certain differences, and we can set a suitable combination of possible scenarios. The Method of allocating 100 points is very closely connected with this described scale. It consists in dividing all one hundred points without any residue between the criteria in accordance with their significance. Here, too, the link applies, the more points the criterion has, the more it is essential for the contracting authority. The phase of determining the weights of the criteria follows. The procedure is that the decision-maker assigns a weight of 1 to the least important criterion and then must determine how many times the penultimate criterion of the preferential order is more significant than the last one. This procedure is only repeated with the third and fourth criteria, of course also in the order from the end. Only in the last step, when we get to the most important criterion, we compare it in relation to the last one. The result is significance coefficients, or non-standard weights. These can still be converted to standard weights using equation (1). The numerator is written in the number of points of the selected criterion and in the denominator the sum of the number of divided points, which can be seen in the formula entered below with an explanation. It is important that the sum of the values of the standard weights is equal to one.

$$v_i = \frac{f_i}{\sum_{i=1}^{n} f_i}, \tag{1}$$

where v_i is the standard weight of the i-th criterion, f_i is number of preferences of the i-th criterion, n specifies the number of criteria.

2.1 Weighted Sum Method

The Weighted Sum Method requires cardinal information, a criterion matrix Y and a vector of criteria weights. It constructs an overall rating for each variant, so it can be used both to find one of the most advantageous variants and to arrange the variants from best to worst. The weighted sum method is a special case of the utility function method. It is based on the principle of maximizing utility. If the variant a_1 reaches a certain value y_{ij} according to the criterion j, it thus brings the user a benefit which can be expressed by means of a linear utility function. The total utility of a variant is expressed by the weighted sum of the values of the partial utility functions

$$u(a_i) = \sum_{i=1}^{m} v_j u_j(y_{ij}), \tag{2}$$

where u_j are the partial functions of the utility of the individual criteria and v_j are the weights of the criteria. The procedure of the weighted sum method is given by the following steps.

We convert minimization criteria to maximization criteria, for example, according to the relation (3) and we thus receive an evaluation for each variant by how much it is better than the worst variant according to the relevant criterion. For simplicity, we will always denote the transformed criterion matrix Y. This adjustment is not necessary, it serves to simplify the next step.

$$y_{ij} = \max_{i=1,\dots,m} \left(y_{ij}\right) - y_{ij}. \tag{3}$$

Then we determine the ideal variant H with evaluation ($h_1, \dots, h_m$) and the basal variant D with evaluation ($d_1, \dots, d_n$). Next, we create a standardized criterion matrix R, the elements of which we obtain using formula (4). The matrix R already represents a matrix of values of the utility function from the *i*-th variant according to the *j*-th criterion, because the elements of this matrix are linearly transformed criterion values such that $r_{ij} \in \langle 0; 1 \rangle$. Then the basal variant corresponds to a value of zero and the ideal variant to a value of one.

$$r_{ij} = \frac{y_{ij} - d_j}{h_j - d_j} \tag{4}$$

For individual variants, we calculate the aggregate utility function according to formula (5). We then sort the variants in descending order according to the values of $u(a_i)$ and consider the required number of variants with the highest values as a solution to the problem.

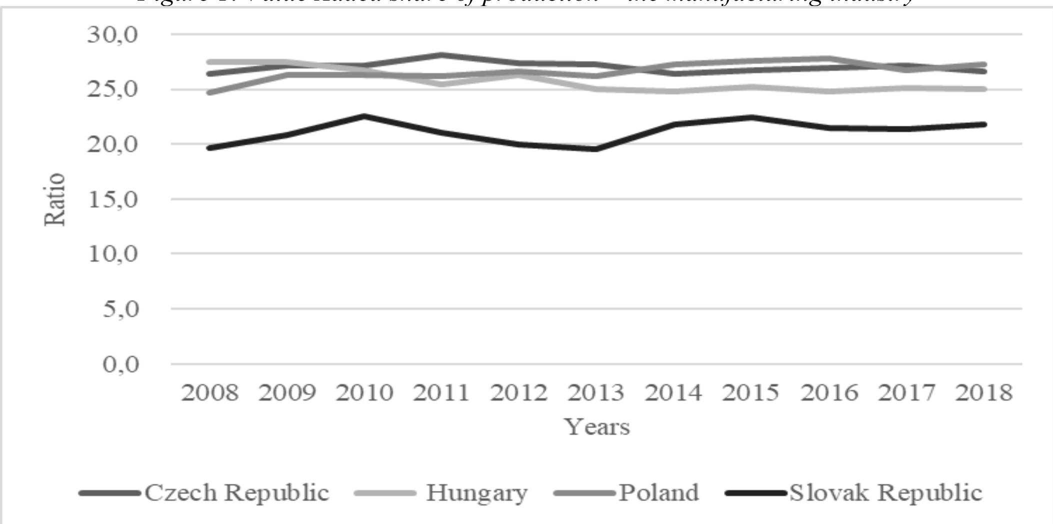
$$u(a_i) = \sum_{j=1}^{n} v_j r_j. \tag{5}$$

3. Data

Data from the OECD database, available on their website, are used to assess the level and development of the manufacturing industry of the V4 countries. Given that the values of some selected indicators for 2019 are not yet listed in OECD statistics, the period 2008 - 2018 will be chosen for the evaluation of the development of the manufacturing industry.

The following figures show the development of selected indicators of the manufacturing industry in the V4 countries over the analyzed period.

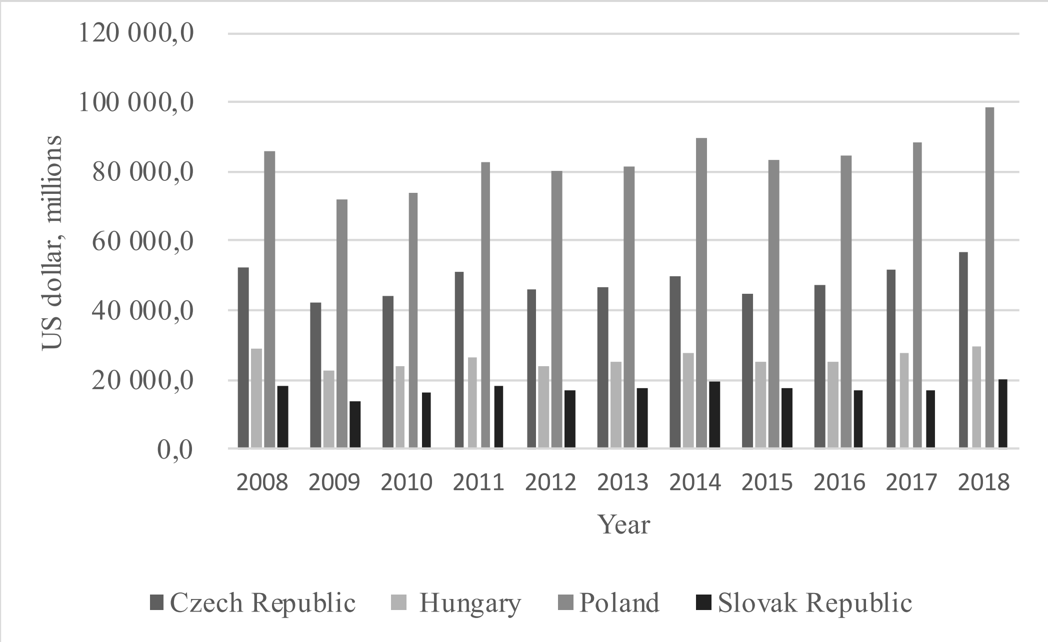
Figure 1: Value Added share of production – the manufacturing industry



Source: OECD database, own processing

Throughout the analyzed period, Slovakia had the lowest share of the value added of the manufacturing industry in the total production. In the other V4 countries, the share of added value of the manufacturing industry in the total production was on average 27 %.

Figure 2: Value Added – the manufacturing industry



Source: OECD database, own processing

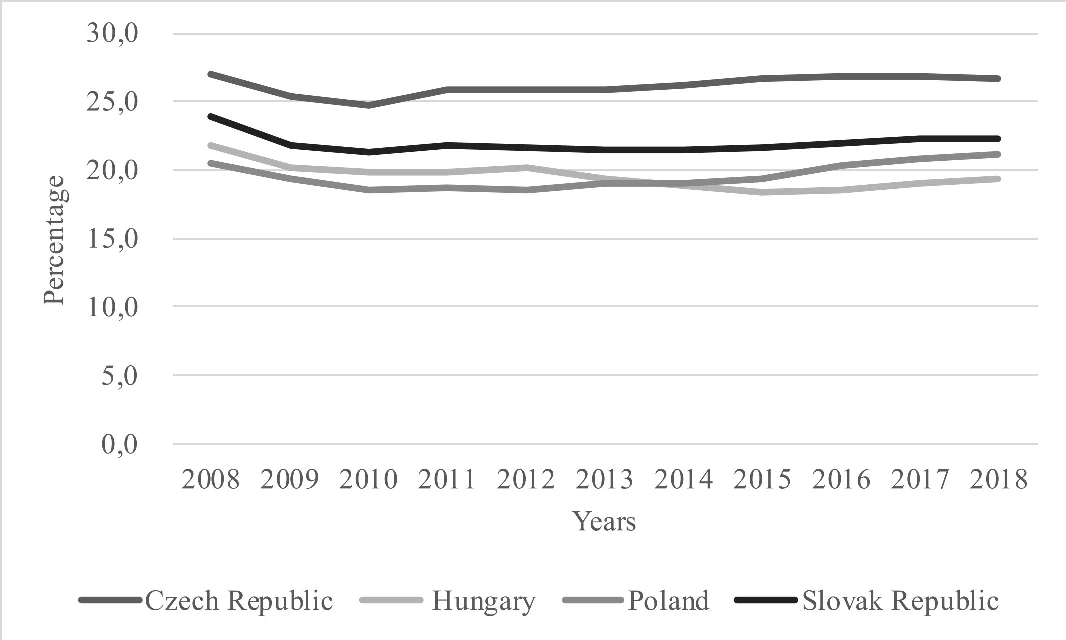
The manufacturing industry in Slovakia created the lowest value added for the entire analyzed period. On the contrary, the manufacturing industry in Poland generated the highest value added.

Figure 3: Gross operating surplus – manufacturing industry

Source: OECD database, own processing

The development of the gross operating surplus in individual economies copies the creation of Value Added. The difference between the amount of Value Added and the value of the gross operating surplus is determined by the size of labor costs (compensation of employees), consumption of fixed capital, taxes less subsidies on production.

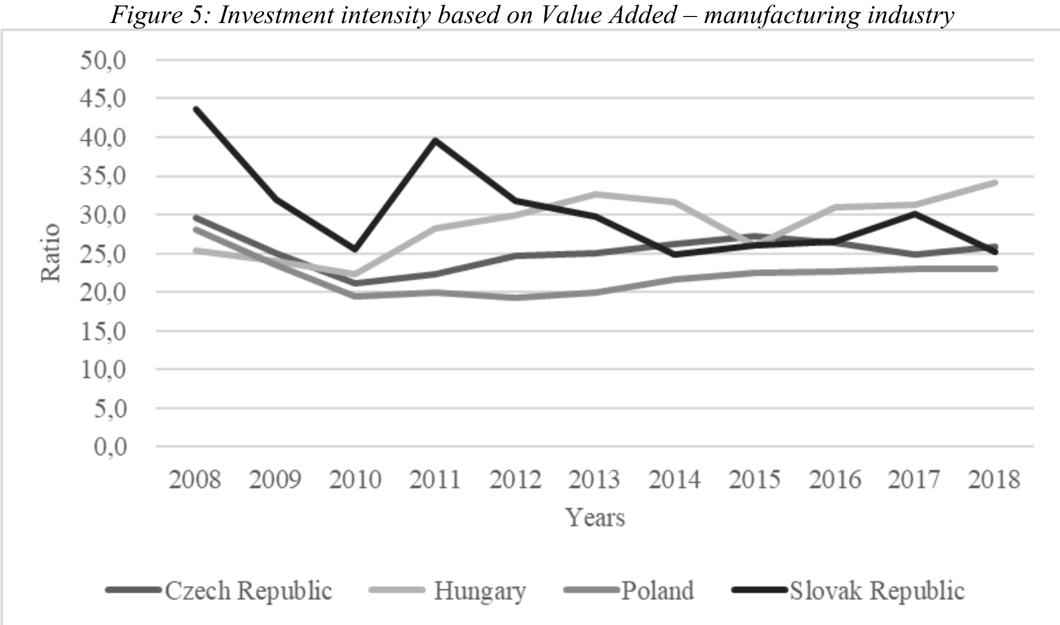
Figure 4: Employment share in total economy – manufacturing industry



Source: OECD database, own processing

The Czech Republic has the highest average employment (26%) in the manufacturing industry of the V4 countries. Slovakia shows 22%, Hungary and Poland only 20%.

Figure 5: Investment intensity based on Value Added – manufacturing industry

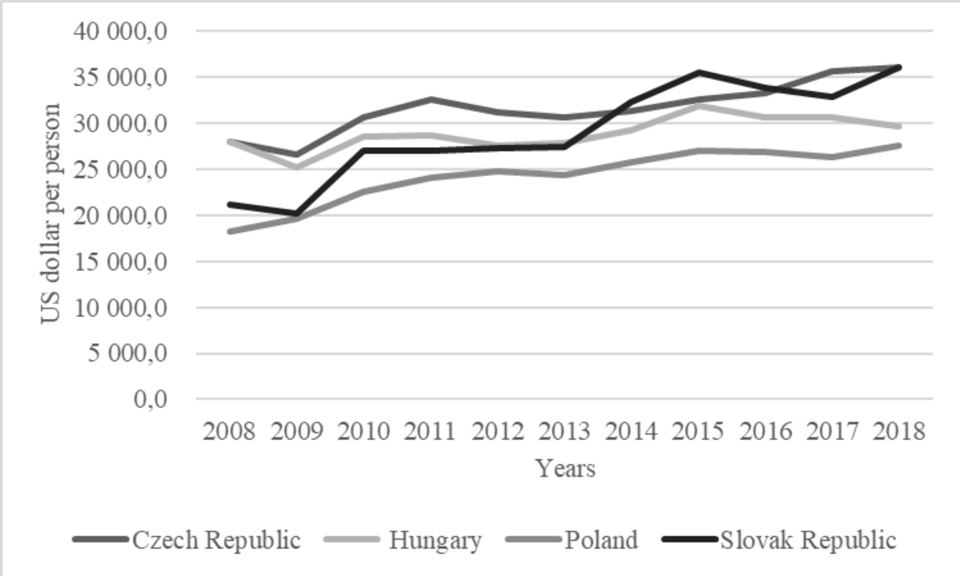


Source: OECD database, own processing

The higher the share of investment intensity in value added, the more capital intensive the sector is and therefore requires more investment to create Value Added.

The highest average value of this indicator was reported by the Slovak Republic (30.5%). Conversely, Poland reported the lowest average value of the indicator (22%). Slovakia showed the highest value of the indicator in 2008, and during the analyzed period the value of this indicator gradually decreased to 25.2%. The second highest average value of the indicator was created by Hungary (29%), and the Czech Republic reported an average 25.3% share of investment intensity on Value Added.

Figure 6: Labour productivity, employment – the manufacturing industry



Source: OECD database, own processing

The Czech Republic, Poland and Slovakia increased labour productivity in the analyzed period. The indicator reached the highest value in these countries in 2018. On the contrary, Hungary showed the highest value of the indicator in 2015, and in subsequent years there was already a decrease in the value of the labour productivity indicator.

4. Results

The manufacturing industry of the V4 countries are evaluated using selected indicators from the above. Relativized indicators, which can be used to evaluate and compare the markets of different economies, seem to be preferable for evaluation. The following are used for evaluation and comparison: the Value Added share of production indicator, the indicator of investment intensity based on Value Added, the labour productivity, employment indicator and the gross operating surplus indicator. The analyzed period is the years 2008–2018.

Using formula (1), the weights of the indicators are first determined.

Table 1: Determination of criteria weights

Indicator	**Score**	**Weight v_i**
Value Added share of production	50	0.50
Investment intensity based on Value Added	25	0.25
Labour productivity, employment	20	0.20
Gross operating surplus	5	0.05
Total	100	1.00

After calculating the weights, the level of the manufacturing industry of the V4 countries and their development are analyzed and evaluated. First, the ideal value of H_j and the basal value of D_j are determined for each indicator and for individual years. Subsequently, the utility values are calculated, which are used to compare individual national manufacturing industry and their development. Formulas (4) and (5) are used for this.

Most of the criteria, indicators, have a maximizing character. However, one of the criteria, specifically the indicator Investment intensity based on Value Added, is a minimization criterion. It is therefore necessary to change it to a maximization criterion by recalculating the values according to formula (3).

Table 2: Evaluation of the manufacturing industry of V4 countries according to the Value Added share of production indicator

Year	H_j	D_j	$r_{ij} \cdot v_j$			
			Czech Republic	**Hungary**	**Poland**	**Slovak Republic**
2008	27.5	19.6	0.43038	0.5	0.316456	0
2009	27.5	20.9	0.477273	0.5	0.409091	0
2010	27.2	22.6	0.5	0.456522	0.402174	0
2011	28.1	21.0	0.5	0.316901	0.359155	0
2012	27.4	20.0	0.5	0.425676	0.452703	0
2013	27.3	19.6	0.5	0.350649	0.428571	0
2014	27.3	21.8	0.418182	0.272727	0.5	0
2015	27.6	22.5	0.411765	0.264706	0.5	0
2016	27.8	21.5	0.428571	0.261905	0.5	0
2017	27.1	21.4	0.5	0.324561	0.464912	0
2018	27.3	21.8	0.445455	0.290909	0.5	0

Table 3: Evaluation of the manufacturing industry of V4 countries according to the investment intensity based on Value Added indicator

Year	H_j	D_j	$r_{ij} \cdot v_j$			
			Czech Republic	**Hungary**	**Poland**	**Slovak Republic**
2008	18.2	0.0	0.192308	0.25	0.212912	0
2009	20.0	11.6	0.205357	0.238095	0.25	0
2010	24.2	17.1	0.18662	0.147887	0.25	0
2011	23.7	4.1	0.219388	0.142857	0.25	0
2012	24.4	11.8	0.142857	0.037698	0.25	0
2013	23.6	10.9	0.149606	0	0.25	0.057087
2014	21.9	11.9	0.1375	0	0.25	0.1725
2015	21.1	16.3	0	0.067708	0.25	0.0625
2016	20.9	12.7	0.140244	0	0.25	0.131098
2017	20.6	12.3	0.195783	0	0.25	0.036145
2018	20.5	9.5	0.186364	0	0.25	0.202273

Table 4: Evaluation of the manufacturing industry of V4 countries according to the labour productivity, employment indicator

Year	H_j	D_j	$r_{ij} \cdot v_j$			
			Czech Republic	**Hungary**	**Poland**	**Slovak Republic**
2008	27 952.3	18 192.3	0.199252	0.2	0	0.060553
2009	26 518.4	19 546.6	0.2	0.16211	0	0.018363
2010	30 644.3	22 583.4	0.2	0.14619	0	0.109169
2011	32 586.7	24 053.9	0.2	0.108	0	0.068671
2012	31 099.4	24 803.5	0.2	0.087813	0	0.077879
2013	30 654.9	24 318.4	0.2	0.10883	0	0.096807
2014	32 237.1	25 777.0	0.171988	0.106206	0	0.2
2015	35 418.9	26 992.0	0.133174	0.116119	0	0.2
2016	33 762.6	26 876.9	0.185195	0.107327	0	0.2
2017	35 593.5	26 276.6	0.2	0.092293	0	0.140645
2018	36 061.7	27 606.9	0.198283	0.047232	0	0.2

Table 5: Evaluation of the manufacturing industry of V4 countries according to the gross operating surplus indicator

Year	H_j	D_j	$r_{ij} \cdot v_j$			
			Czech Republic	**Hungary**	**Poland**	**Slovak Republic**
2008	41 172.3	9 923.0	0.024858	0.006816	0.05	0
2009	39 271.6	6 223.4	0.022358	0.007348	0.05	0
2010	38 183.9	9 211.1	0.022463	0.005575	0.05	0
2011	44 496.4	9 966.4	0.022703	0.00479	0.05	0
2012	43 735.4	9 217.2	0.019351	0.003898	0.05	0
2013	42 594.2	8 961.0	0.020948	0.006169	0.05	0
2014	48 597.9	10 725.7	0.020686	0.005362	0.05	0
2015	47 321.4	9 469.9	0.019107	0.006113	0.05	0
2016	45 893.5	8 291.3	0.021455	0.006595	0.05	0
2017	44 760.5	7 574.9	0.024011	0.008852	0.05	0
2018	48 048.3	8 971.4	0.022032	0.006647	0.05	0

Table 6: Evaluation of the manufacturing industry of V4 countries

Year	Czech Republic	Hungary	Poland	Slovak Republic	Total
2008	0.846797	0.956816	0.579368	0.060553	**2.443534**
2009	0.904988	0.907553	0.709091	0.018363	**2.539995**
2010	0.909083	0.756174	0.702174	0.109169	**2.4766**
2011	0.942091	0.572548	0.659155	0.068671	**2.242466**
2012	0.862208	0.555084	0.752703	0.077879	**2.247874**
2013	0.870554	0.465648	0.728571	0.153894	**2.218667**
2014	0.748356	0.384295	0.8	0.3725	**2.305151**
2015	0.564045	0.454645	0.8	0.2625	**2.081191**
2016	0.775466	0.375826	0.8	0.331098	**2.282389**
2017	0.919795	0.425706	0.764912	0.17679	**2.287203**
2018	0.852133	0.344789	0.8	0.402273	**2.399194**
Total	**9.195515**	**6.199085**	**8.095974**	**2.03369**	

From the values calculated above, it is possible to evaluate the development of the manufacturing industry in the Czech Republic as the best. The manufacturing industry of the Poland and Hungary reaches lower values. The lowest values are reached by the Slovak Republic manufacturing industry.

5. Conclusions

The aim of the article was to analyze, compare and evaluate the situation and development in the manufacturing industry of the V4 countries in 2008–2018. The indicators used to compare the manufacturing industry of individual countries were Value Added share of production, Value Added, Gross operating surplus, Employment share in total economy, Investment intensity based on Value Added and Labour productivity, employment indicator. Their values for the observed period were obtained from the OECD database. Subsequently, the manufacturing industry were assessed on the basis of selected indicators using methods of multi-criteria analysis.

By applying a modified Scoring method, the Method of allocating 100 points, the preference of selected indicators was determined. The most important indicator with the highest preference was the Value Added share of production indicator with a weight of 0.5. A weight of 0.25 was calculated for the Investment intensity based on Value Added indicator and the preference 0.2 was determined for the Labour productivity employment indicator. The Gross operating surplus indicator with a weight of 0.05 was determined to be the least important.

Based on the application of the Weighted Sum Method, the development of the manufacturing industry in the Czech Republic can be evaluated as the best, the development in the Slovak Republic appears to be the worst, according to the calculated values.

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Pension system in Czech Republic Assessment by Applying Decomposition Multi-Criteria Methods

Martina Borovcová [1]

Abstract

The aim of the article is to analyze, compare and evaluate the situation and development of the pension system in the Czech Republic in the period 2010-2020. Selected indicators of the pension system evaluation will be used for the performed analysis and subsequent evaluation. Their values for the monitored period will be obtained from the OECD database. Subsequently, the pension system will be evaluated based on selected indicators using multi-criteria analysis methods.

Key words

Pension system, indicator, multi-criteria analysis methods

JEL Classification: G22, H75, O10

1. Introduction

Pension systems and their functioning are increasingly the subject of not only scientific but also political professional discussions in most European countries. The reason is primarily unsustainability current system settings. These are based in a large number of cases on an ongoing basis financing, which, however, due to the development of demographic factors, appears prospective insufficient. This is because the ratio of citizens of working age (15 to 64 years) to retired citizens (over 65 years) is decreasing. In 2013, the ratio was four workers to one pensioner, which is not a very high number. However, by 2060, the given ratio is expected to drop to the value of two workers to one pensioner, which is already an alarming ratio (European Commission 2015).

This is primarily due to a reduced birth rate on the one hand and a longer lifespan on the other. As a result of the lower birth rate, the number of young people entering the labor market is decreasing. The consequence of a longer lifespan is higher financial demands on pension systems and their resources. Various financial or economic crises, which have an impact mainly on fund-financed systems, which reduce the value of assets and their returns, do not contribute to the improvement of the situation. It is therefore necessary to set up the pension system appropriately in order to eliminate these problems or reduce their impact. This can subsequently have a positive effect not only on the pensioners themselves and their incomes, but also on workers, as there will be no further financial burden on them through tax increases. Currently, however, there is no simple guide or model according to which it would be possible to simply choose the ideal system for specific countries. For that reason, it is most appropriate to analyze the pension systems of other countries, to be inspired and to learn from their implementation and functioning, so that only those elements of the system that appear to be beneficial are subsequently applied.

The article is therefore focused on assessing and evaluating the development of the pension system in the Czech Republic. The evaluated time horizon is the period 2010 - 2020.

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2. Pension system

The pension systems of individual economies are not the same. Their construction, functioning and financing may differ. It is therefore most appropriate to briefly describe pension systems. Basic classifications will be used for this.

2.1 Classification of pension systems by operator

The operation of the pension system in most countries is divided between the public and private sectors. The weight of private and public pillars of individual sectors is very different.

The public operator of pension systems is most often the state. The government is thus responsible for the collection of contributions and the actual payment of pensions (Thoys 2010, p. 227). The state-guaranteed pension comes in two different forms, a flat-rate pension and an earnings-related pension. Flat-rate pension (also flat-rate) means that all participants are entitled to the same amount of benefit, regardless of the level of earnings at the time of their economic activity. On the other hand, the earnings-related pension depends on the amount of wages at a time when the participants were economically active. In the second case, the private person is responsible for collecting contributions and paying benefits sector. This is organized either at the level of employers or at the level of individuals participants who save in individual accounts managed by pension funds. Saved up they can then use the funds in their old age (Bezděk 2000, p. 62).

2.2 Classification of pension systems according to their financing

Although this classification is one of the most used, it is not completely uniform, as it is interpreted differently by different authors. This is based primarily on the breakdown published by, for example, Krebs (2015), whose system offers a comprehensive view of the issue.

The first possibility of financing is drawing funds from the state budget. The source can be income taxes, where the highest possible level of solidarity is applied, since the tax burden increases with increasing income, but the level of pension decreases compared to increasing earnings. Another source can also be a social pension insurance contribution, the amount of which is determined by a uniform percentage of earnings. There is therefore a lower degree of social redistribution than in the first case. Contribution income should be set to cover pension costs over a period. This should make the system more transparent and flexible (Krebs 2015, p. 196).

Another option is financing through a fund that is separate from the state budget. It is a system based on intergenerational solidarity, as economically active individuals regularly pay contributions to social insurance, from which pensions are subsequently paid to current retirees. The pensions of working people will then be paid from the contributions of today's children (Bezděk 2010). This is a case of continuous financing, also called pay as you go (PAYG), which is used by most foreign systems. According to Krebs (2015, p. 198), this system can also have two forms. In the first case, no capital reserve is created within the system, which could be invested and the profit from investments redistributed further. If the collected funds are not sufficient to cover pensions, the system must be subsidized from the state budget. The second option is a system that achieves or has achieved surpluses. These are further invested on the capital market and bring with them a return that can be used to finance benefits or in the event of a lack of funds in a given year. In the case of fund financing, responsibility passes from the state to the insured himself. Insureds themselves create capital reserves, which are later used to finance their own pensions. The amount of the pension depends on the amount of accumulated contributions. This system does not rely on intergenerational solidarity and is very common in private insurance systems (Krebs 2015, 195).

2.3 Classification of pension systems according to the type of pension plan

The type of pension plan refers to the definition of the relationship between the contribution and the benefit. The pension system can be defined benefit, defined contribution or so-called hypothetical defined contribution.

The defined benefit pension system guarantees a certain amount of pension benefit in retirement, which is derived from several factors. These include the number of years for which the individual has contributed to the system, the amount of his income and the amount of the current parameters established by law. Due to the development of demographic variables, especially the overall aging of the population, the given system is falling behind due to its financial demands (Booth, P., Chadburn, R., Haberman S., James D., Khorasanee Z., Plumb R.H. and Rickayzen, B. 2005, p. 563).

In the case of defined contribution systems, the exact amount of contributions to be paid by the participant is determined. However, the amount of future benefits paid out is no longer guaranteed. It depends on the amount of contributions paid during participation in the system and on rate of return on investing in the capital market. This can lead to both a valorization of benefits and a decrease in them (Krebs 2015, p. 198).

There is also a hypothetical defined contribution system, known in the literature as NDC (notional defined contribution). Its essence is that each of the participants has his own individual hypothetical account, to which he is credited with the contributions he has made and their appreciation over time, which depends on the hypothetical rate of return. The amount of the pension then depends on the apparent savings in the account and the average life expectancy of pensioners in the given period. Savings are called hypothetical, as they are already used for the payment of current pensions during the saving process, and are thus only formally recorded in the individual accounts of the participants (Bezděk 2000, p. 14).

2.4 Classification of pension systems according to the tax environment

Three basic approaches are also presented here. One of them is the EET system, under which contributions paid into the system and investment income realized from them are exempt from tax. Only the pension itself is subject to income tax. This means that the contributions are a tax-deductible item, the income from them is not taxed after being credited to the account, but the entire pension paid is then subject to income tax.

The second form is the so-called TEE system, where contributions to the system are not tax-deductible and are thus paid from the salary after taxation. Income from investments and paid pensions are then no longer taxed (Bezděk 2000, p. 15).

The third form is the ETT system, which is essentially the opposite of the TEE system. Contributions can thus be tax-deductible, however, both income from investments and paid pensions are already subject to tax (European Commission 2016).

3. Description of the Czech pension system

The Czech pension system consists of two parts. The first pillar is the mandatory basic pension insurance**,** defined by benefits (DB) and funded on a running basis (pay-as-you-go = PAYGO). The system is universal and provides for all economically active individuals; the legal regulation is the same for all the insured persons, there are no industry-specific schemes etc. Only in the area of organizational and administrative provision there are some variations in the so-called power sectors (e.g. soldiers, policemen, customs officers, firefighters). The pension from the basic pension insurance is drawn by more than 99 % of the population whose age is higher that the retirement age.

In addition, there is a voluntary complementary additional pension insurance with state contributions**,** defined by contributions (DC), capital funded. The additional pension insurance can be, according to the EU terminology, considered the third pillar of the pension system. The third pillar also includes products offered by commercial insurance companies – particularly life insurance. Pensions granted from the third pillar so far represent only a negligible portion of incomes of the retired. The second pillar, which is usual in EU member states (employer pension schemes), is absent in the Czech pension insurance system.

The following pensions are provided from the basic pension insurance:

- old-age (including the so-called early old-age pension),
- disability,
- widow and widower,
- orphan.

Each pension consists of the following components:

- a basic assessment (which is a fixed amount identical for all types of pensions, regardless of the insurance duration and income) and
- a percentage assessment.

If conditions which entitle a person to several pensions of the same type have been met or payment of old-age pension or disability pension, then only one type of the pension will be paid, specifically the higher one. If conditions have been met which entitle a person to old-age or disability pension and to widow or widower pension or orphan pension, then the higher one shall be paid in the full amount and one half of the percentage assessment shall be paid from the other pensions, unless the Act on pension insurance establishes otherwise.

The decision about the entitlement to a pension, its amount and payment shall be made by the Czech Social Security Administration (Česká správa sociálního zabezpečení), with the exception of cases where the decision is made by competent social security bodies of the Ministries of Defense, Interior and Justice (in case of members of armed forces and corps).

3.1 Development of the Czech pension system

In the past decades the Czech society and economy and with it the Czech pension system have been significantly transformed. In 1989, Czechoslovakia returned to democracy in the Velvet Revolution, in 1993 the Czech Republic and the Slovak Republic split into two independent countries and, in 2004, the Czech Republic joined the European Union.

The pension reform process started immediately after the political changes in 1989.1 Czechoslovakia wanted to create a unified social security system, which would provide health, sickness and pension benefits. The three labour categories that existed under communist rule were unified and the self-employed were included in the pension system. In addition, the pension system shifted from a tax-financed to a contribution-financed scheme in 1992. The inception of the new pension system took place in 1995 with the enacting of the Pension Insurance Act. Since then, there have been significant reforms in 2003, 2008, 2011 and 2016.

While various changes have been implemented over the last 25 years, the architecture and principles in the design of the Czech pension system have been mainly unaltered since the 1995 Pension Insurance Act. The mandatory contributory system consists of an earnings-related component and a basic, flat-rate component. The earnings-related component is calculated by multiplying the reference wage with total accrual. A very progressive formula is used to calculate the reference wage as a function of wages throughout the career, effectively reducing accrual rates for high average wages. Some non-employment spells count towards accrual while others do not and enter on top as zeros in the calculation of the reference (average) wage. Everyone who is eligible for the earnings-related component receives the basic pension.

In 2019, the Minister of Labour and Social Affairs established the Commission for Fair Pensions, tasked with reforming the pension system to ensure a financially sustainable pension system that at the same time delivers adequate pensions. The Commission consists of representatives from academia, public bodies, social partners, political parties and interest groups. In January 2020, it published its first pension reform proposal (European Commission 2021).

4. Methodology

Multi-criteria evaluation methods are used to fulfill the set goal. They describe multi-criteria decision-making methods in their publications (Brožová, Houška, Šubrt 2014), (Ishizaka, Nemery 2013), (Raju, Kumar 2014) and (Doumpos, Zopounidis 2014).

First, the weights of the criteria, i.e. indicators for evaluating the level of pension systems, are determined. Subsequently, there will be a comparison of variants, i.e. individual years of the observed period of development of the pension system in the Czech Republic.

The method of direct determination of criteria weights is used to determine the weights of criteria. This is a modified Scoring method, a Method of allocating 100 points. This method is based on assigning points to individual criteria based on the decision-maker's preferences. It consists in dividing all one hundred points without any residue between the criteria in accordance with their significance. The result is significance coefficients, or non-standard weights. These can still be converted to standard weights using equation (1). The numerator is written in the number of points of the selected criterion and in the denominator the sum of the number of divided points, which can be seen in the formula entered below with an explanation. It is important that the sum of the values of the standard weights is equal to one.

The weighted sum method is used to compare variants. These methods are briefly described in the following text.

$$v_i = \frac{f_i}{\sum_{i=1}^{n} f_i}, \tag{1}$$

where v_i is the standard weight of the *i*-th criterion, f_i is number of preferences of the *i*-th criterion, *n* specifies the number of criteria.

4.1 Weighted Sum Method

The Weighted Sum Method requires cardinal information, a criterion matrix *Y* and a vector of criteria weights. It constructs an overall rating for each variant, so it can be used both to find one of the most advantageous variants and to arrange the variants from best to worst. The weighted sum method is a special case of the utility function method. It is based on the principle of maximizing utility. If the variant a_1 reaches a certain value y_{ij} according to the criterion *j,* it thus brings the user a benefit which can be expressed by means of a linear utility function. The total utility of a variant is expressed by the weighted sum of the values of the partial utility functions

$$u(a_i) = \sum_{i=1}^{m} v_j u_j(y_{ij}), \tag{2}$$

where u_j are the partial functions of the utility of the individual criteria and v_j are the weights of the criteria. The procedure of the weighted sum method is given by the following steps.

We convert minimization criteria to maximization criteria, for example, according to the relation (3) and we thus receive an evaluation for each variant by how much it is better than the worst variant according to the relevant criterion. For simplicity, we will always denote the transformed criterion matrix Y. This adjustment is not necessary, it serves to simplify the next step.

$$y_{ij} = \max_{i=1,\dots,m}\left(y_{ij}\right) - y_{ij}. \tag{3}$$

Then we determine the ideal variant H with evaluation ($h_1, \ldots, h_m$) and the basal variant D with evaluation ($d_1, \ldots, d_n$). Next, we create a standardized criterion matrix *R*, the elements of which we obtain using formula (4). The matrix R already represents a matrix of values of the utility function from the *i*-th variant according to the *j*-th criterion, because the elements of this matrix are linearly transformed criterion values such that $r_{ij} \in \langle 0; 1 \rangle$. Then the basal variant corresponds to a value of zero and the ideal variant to a value of one.

$$r_{ij} = \frac{y_{ij} - d_j}{h_j - d_j} \tag{4}$$

For individual variants, we calculate the aggregate utility function according to formula (5). We then sort the variants in descending order according to the values of $u(a_i)$ and consider the required number of variants with the highest values as a solution to the problem.

$$u(a_i) = \sum_{j=1}^{n} v_j r_j. \tag{5}$$

5. Data

Data from the OECD database, available on their websites, are used to assess the level and development of the pension system in Czech Republic 2010–2020.

The following indicators were selected to assess the level and development of the pension system in the Czech Republic: Contributions as a share of GDP (%), Benefits paid as a % of DGP, Assets as a share of GDP (%), Employees´contributions as a % of total contributions, Employers´contributions as a % of total contributions, Investment expenses as a % of total assets. The following figures show the development of the indicators.

Figure 1: The development of the selected indicators (%)

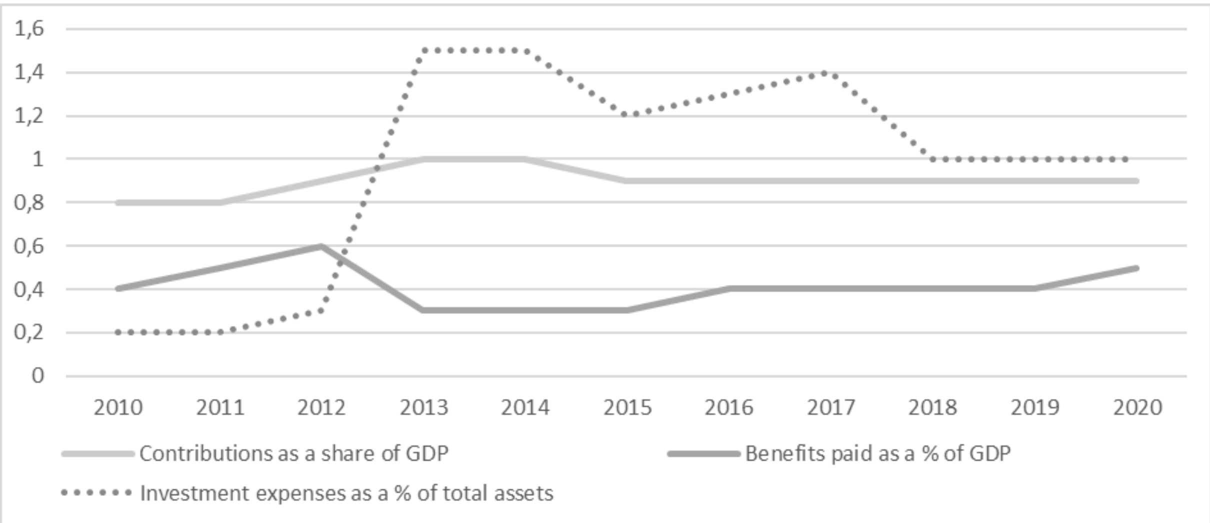
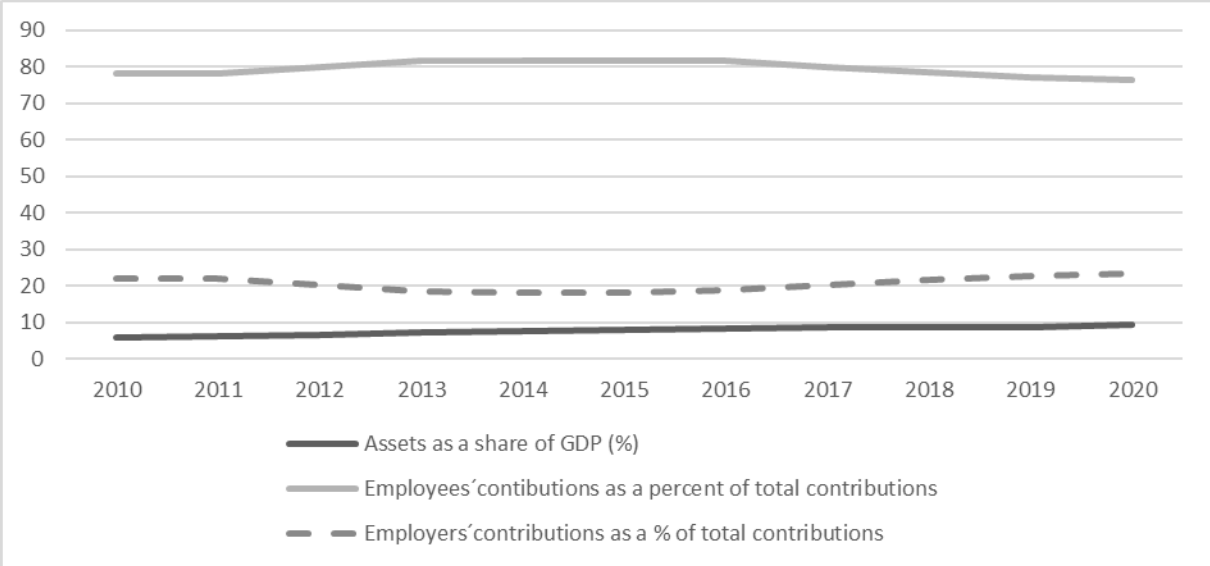


Figure 2: The development of the selected indicators (%)



6. Results

Based on the above selected indicators, the development of the Czech pension system is subsequently analyzed and evaluated. The period 2010–2020 is analyzed.

Using formula (1), the weights of the selected indicators are first determined.

Table 1: Determination of criteria weights

	Indicator	Score	Weight v_i
Indicator 1	Contribution as a share of GDP (%)	37	0.37
Indicator 2	Benefits paid as a % of GDP	27	0.27
Indicator 3	Assets as a share of GDP (%)	17	0.17
Indicator 4	Employees´ contribution as a % of total contributions	9	0.09
Indicator 5	Employers´ contributions as a % of total contributions	6	0.06
Indicator 6	Investment expenses as a % of total assets	4	0.04
	Total	100	1.00

After calculating the weights, the development of the Czech pension system in the individual years of the analyzed period is analyzed and evaluated. First, the ideal value of H_j and the basal value of D_j are determined for each indicator and for individual years. Subsequently, the utility values are calculated, which are used to compare individual national insurance markets and their development. Formulas (3), (4) and (5) are used for this. Formula (3) was specifically used to convert the indicator Benefits paid as a % of GDP and Investment expenses as a % of total assets.

Table 2: Development of the values of the evaluation indicators of the Czech pension system

Year	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
2010	0.8	0.2	5.8	78.1	21.9	1.3
2011	0.8	0.1	6.1	78.1	21.9	1.3
2012	0.9	0.0	6.7	79.8	20.2	1.2
2013	1.0	0.3	7.2	81.6	18.4	0.0
2014	1.0	0.3	7.8	81.8	18.2	0.0
2015	0.9	0.3	8.1	81.8	18.2	0.3
2016	0.9	0.2	8.4	81.8	18.9	0.2
2017	0.9	0.2	8.7	79.9	20.1	0.1
2018	0.9	0.2	8.7	78.5	21.5	0.5
2019	0.9	0.2	8.8	77.3	22.7	0.5
2020	0.9	0.1	9.5	76.6	23.4	0.5
H_j	1	0.3	9.5	81.8	23.4	1.3
D_j	0.8	0	5.8	76.6	18.2	0

The resulting values of the indicators as well as the total values of the individual years of the monitored period are shown in Table 3. Both the periods with the highest achieved values of the individual indicators and the best analyzed year are highlighted.

Table 3: Evaluation of the development of the pension system in the Czech Republic

Year	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6	Total
2010	0	0.18	0	0.025962	0.042692	0.04	0.288654
2011	0	0.09	0.013784	0.025962	0.042692	0.04	0.212438
2012	0.185	0	0.041351	0.055385	0.023077	0.036923	0.341736
2013	0.37	0.27	0.064324	0.086538	0.002308	0	0.79317
2014	0.37	0.27	0.091892	0.09	0	0	0.821892
2015	0.185	0.27	0.105676	0.09	0	0.009231	0.659906
2016	0.185	0.18	0.119459	0.09	0.008077	0.006154	0.58869
2017	0.185	0.18	0.133243	0.057115	0.021923	0.003077	0.580359
2018	0.185	0.18	0.133243	0.032885	0.038077	0.015385	0.584589
2019	0.185	0.18	0.137838	0.012115	0.051923	0.015385	0.582261
2020	0.185	0.09	0.17	0	0.06	0.015385	0.520385

From the values shown in Table 3, it is possible to analyze the situation and development of the pension system in the Czech Republic in the period 2010-2020. From the results of the selected indicators, it is clear that the situation is developing positively until 2014, but from this year onwards it worsens significantly and in 2020 it is at the level of 2012-2013, while the tendency is further deteriorating.

7. Conclusions

The aim of the article was to analyze, compare and evaluate the situation and development of the pension system in the Czech Republic for the period 2010-2020. Selected indicators of the pension system evaluation were used for possible analysis and subsequent evaluation. Their values for the observed period were obtained from the OECD database. Subsequently, pension system were assessed on the basis of selected indicators using methods of multi-criteria analysis.

Based on the application of the weighted sum method, the development of the pension system in the Czech Republic for the period 2010-2020 cannot be assessed as good or satisfactory. The development has a desirable trend only until 2014, after which it deteriorates. This fact will be the subject of further research.

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Impacts of pandemic portfolio re-optimization on the market with open-end mutual funds: mixed moving mean-absolute negative deviation-entry fee model

Adam Borovička [1], Josef Nový [2]

Abstract

The COVID-19 pandemic, as a global shock, affects people all over the world in various spheres of their lives. One of them is certainly investing. With the outbreak of the pandemic, we have seen sell-offs on stock exchanges around the world. This paper seeks to highlight the changes in investment behaviour and their implications for investment performance under the extreme conditions, with a focus on the market with open-end mutual funds. For this purpose, the mixed moving mean-absolute negative deviation-entry fee model is proposed. This model can effectively absorb the price dynamics through the implementation of moving averages. Integrated mechanism recalculates the costs associated with the replacement of open-end mutual funds within a restructuring process triggered by a market shock. The model also reflects changing investor preferences (attitude to risk, etc.) that is naturally induced by an extreme situation. The effect of pandemic re-optimization is analysed using data from open-end mutual funds offered by Česká spořitelna. The portfolios produced are compared on their composition and characteristics. The sensitivity to change, and hence its justifiability, is analysed.

Key words

Moving, open-end mutual fund, pandemic, portfolio, re-optimization.

JEL Classification: C44, C61, G11

1. Introduction

Investing is a growing phenomenon, even in less developed parts of the world. It is already an inherent part of the lives of humanity. So, it is not surprising that, with the advent of global, unexpected, often catastrophic events, this activity is also being dramatically affected. This was no different during the outbreak of the COVID-19 pandemic. The significant uncertainty associated with the arrival of an unknown, highly contagious disease caused a major shift in investor sentiment. In late February and March 2020, fearing an uncertain future, a wave of stock market sell-offs took place around the world (Forbes, 2021).

The article focuses on the empirical analysis of the impacts of a radical change in investment behaviour under extreme conditions stimulated by the global shock. Then the essential goals of the paper can be seen in the answers to the following research questions: (i) What is the impact of a sudden change in investment behaviour, and hence investment strategy, or preferences, on the form of investment? How does the portfolio composition after restructuring differ from the original form? (ii) How does the revised portfolio perform over

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time in terms of the observed characteristics compared to the original portfolio? (iii) What methodological approach should be proposed to analyse the impact of portfolio re-optimization induced by a global shock?

Of course, empirical analysis cannot do without a real-life investment decision making situation. The author's personal interest in the still booming market of collective investment is directed to open-end mutual funds, which are increasingly popular not only in the Czech Republic. The empirical analysis reflects a problem very close to investment practice, which is solved by thousands and thousands of investors on the Czech capital market. Rather, it is a longer-term, investment strategy, the aim of which is the appreciation of free funds for the purpose of at least partial financial security, especially at retirement age, when it is not reasonable to rely only on the state pension. Let us simulate the situation of investing in open-end mutual funds in the pre-pandemic time. After a pandemic outbreak, the investment policy is reassessed and the investor's preferences change. The portfolio is restructured based on new data or circumstances.

In order to do an empirical analysis, the methodological framework must be established. There is no doubt that we always keep two characteristics in mind when investing – return and risk. It is then proposed to use the notorious two-factor mean-variance model (Markowitz, 1952, 1959), which make a portfolio based on the investor's 'return-risk' profile. However, there are several well-known obstacles to the application of this model. The assumption of normality of asset returns is often too strong as evidenced by a number of empirical studies, from Simkowitz and Beedles (1978) to Borovička (2021b). Variance as a measure of risk penalizes negative and positive deviations from the mean equally. As discussed (e.g.) by Swisher and Kasten (2005), such a view is simplistic. The risk function is non-linear, which can make finding the optimal solution difficult. Investment in open-end mutual funds requires the explicit inclusion of at least one more criterion – cost, because investing in these funds is burdened by number of fees. Finally, return and risk are comprehended statically. Means and (co)variances are determined from historical data. They are not assumed to evolve. This stability, especially in such turbulent times of global shocks, partially detaches the model from reality.

One of the stated goals is to propose such a model that eliminates all these shortcomings. Variance as a risk measure is replaced by a linear absolute negative deviation concept inspired by Konno and Yamazaki 's absolute deviation (Konno and Yamazaki, 1991). The linearity of the model simplifies the (re-)optimization process. On the other hand, it is worth noting the potential drawback that the absence of covariances makes it impossible to capture the effect between returns. The potential instability of investment characteristics is incorporated into the model through the concept of moving averages, as first elaborated by Borovička (2021a). Thus, the historical period is divided into partially overlapping subperiods. In each subperiod, local investment characteristics are computed. Finally, the return, or risk is determined as a moving average of all local means, or absolute negative deviations. This approach of expressing instability is very user-friendly compared to the use (e.g.) fuzzy sets (Borovička, 2021b; Huang, 2007; Para et al., 2001). Furthermore, a third investment characteristic cost is included in the model. This is usually an entry fee, which is paid at the beginning of the investment in the open-end mutual funds. The cost characteristic is seen as static due to its mostly negligible variability over time. The model is designed in a multi-criteria manner with an aggregate objective function, which is conceived as a weighted sum of functional characteristics. This formulation then allows preferences to be expressed regarding the importance of individual characteristics. It is then no longer necessary to explicitly set the required minimum level of return or maximum level of risk, which can be more pleasant for the less experienced investor in particular. The model designed with all the above mentioned improvements, or features, is aptly called as mixed moving mean-absolute negative deviation-entry fee model.

The developed model is the main tool of the entire decision-making procedure, which starts with the determination of the investment policy, continues with the creation of the investment portfolio, followed by a revision due to some unexpected event, ending with an evaluation of the investment performance over time. This developed procedure is applied to open-end mutual funds offered by Česká spořitelna. The results show that the revision of the portfolio in the light of pandemic developments has a significant impact on the portfolio composition. Thus, the threat ‘something unknown’, very dangerous, can significantly influence investment behaviour, hence the form of investment. Although this is a short period of time for medium- to long-term investments, more than two years after the outbreak of the pandemic, the decision to re-optimize appears beneficial based on portfolio performance.

The structure of the article is as follows. After Introduction, the portfolio (re)optimization approach for the empirical analysis is proposed (Section 2). The pandemic portfolio restructuring with open-end mutual funds are demonstrated in Section 3. Finally, the theoretical and practical contributions of the article are summarized. Interesting ideas for future research are outlined.

2. Portfolio (re-)optimization approach based on the mixed moving mean-absolute negative deviation-entry fee model

Investment strategy is the cornerstone of any investment plan. It is shaped by the purpose of the investment, attitude to risk, perception of investment performance, style of management, etc. In accordance with the investment strategy, an investment portfolio is made as the output of a multi-factor analysis. For this purpose, the mixed moving mean-absolute negative deviation-entry fee model is proposed as a basic pillar of the whole process of making a portfolio adapted to the market with open-end mutual funds. This developed methodological tool is also adapted to the (sudden) need for portfolio reconstruction, which may be triggered by an external shock, such as the outbreak of financial crises, insidious disease or war conflict.

2.1 Mixed moving mean-absolute negative deviation-entry fee model

Based on the methodological review from the introductory section, the mixed moving mean-absolute negative deviation-entry fee model is designed in the following form

$$\begin{aligned} \max \quad & w_1 \frac{\mathbf{r}^{\mathbf{T}}\mathbf{x} - r_{\min}}{r_{max} - r_{min}} + w_2 \frac{l_{\max} - \mathbf{l}^{\mathbf{T}}\mathbf{x}}{l_{max} - l_{\min}} + w_3 \frac{c_{\max} - \mathbf{c}^{\mathbf{T}}\mathbf{x}}{c_{max} - c_{min}} \\ & \mathbf{x} \in X, \end{aligned} \tag{1}$$

where the vector $\mathbf{r}^{\mathbf{T}} = (r_1, r_2, ..., r_M)$, $\mathbf{l}^{\mathbf{T}} = (l_1, l_2, ..., l_M)$ and $\mathbf{c}^{\mathbf{T}} = (c_1, c_2, ..., c_M)$ includes the return, risk and cost of *M* open-end mutual funds, $\mathbf{x} = (x_1, x_2, ..., x_M)^T$ contains the shares of *M* mutual funds. w_1, w_2 and w_3 is the weight of portfolio return, risk and cost expressed by $\mathbf{r}^{\mathbf{T}}\mathbf{x}$, $\mathbf{l}^{\mathbf{T}}\mathbf{x}$ and $\mathbf{c}^{\mathbf{T}}\mathbf{x}$. The weights reflect the investor’s preferences regarding the importance of the investment characteristics. All necessary conditions of a real investment situation are created the set of the feasible solutions *X*. The set always consists of non-negativity conditions for the variables $\mathbf{x} \geq \mathbf{0}$, and also the portfolio condition $\sum_{j=1}^{3} w_j = 1$. The set can be extended according to the needs of the real-life investment case, e.g. by requiring a minimum/maximum share of the asset in the portfolio, etc.

In general, the values of the characteristics can vary in different units, orders of magnitude, or value intervals. In order to achieve uniformity, the characteristics are normalised by a technique considering the smallest and greatest value of the characteristics concerned under specified conditions. This technique leaves the original character of the data, even in the case of negative values. Thus, the best (ideal) values of return $r_{max} = \mathbf{r}^{\mathbf{T}}\mathbf{x}_{\mathbf{r}}^{*}$, risk $l_{min} = \mathbf{l}^{\mathbf{T}}\mathbf{x}_{\mathbf{l}}^{*}$ and cost $c_{min} = \mathbf{c}^{\mathbf{T}}\mathbf{x}_{\mathbf{c}}^{*}$ are determined through the following

$$\begin{array}{lll} \mathbf{x}_{\mathbf{r}}^{*} = \arg\max \mathbf{r}^{\mathbf{T}}\mathbf{x} & \mathbf{x}_{\mathbf{l}}^{*} = \arg\min \mathbf{l}^{\mathbf{T}}\mathbf{x} & \mathbf{x}_{\mathbf{c}}^{*} = \arg\min \mathbf{c}^{\mathbf{T}}\mathbf{x} \\ \mathbf{x} \in X, & \mathbf{x} \in X, & \mathbf{x} \in X. \end{array} \tag{2}$$

The worst possible (basal) value of the investment characteristics is not determined by the opposite extreme. Such an approach would potentially be unnecessarily pessimistic in the context of a multi-criteria problem. The basal value of the relevant characteristic is then determined with respect to the possible values of the other characteristics. Then the following holds

$$r_{min} = \min\left(\mathbf{r}^{\mathbf{T}}\mathbf{x}_{\mathbf{l}}^{*}, \mathbf{r}^{\mathbf{T}}\mathbf{x}_{\mathbf{c}}^{*}\right), \qquad l_{max} = \max\left(\mathbf{l}^{\mathbf{T}}\mathbf{x}_{\mathbf{r}}^{*}, \mathbf{l}^{\mathbf{T}}\mathbf{x}_{\mathbf{c}}^{*}\right), \qquad c_{max} = \max\left(\mathbf{c}^{\mathbf{T}}\mathbf{x}_{\mathbf{r}}^{*}, \mathbf{c}^{\mathbf{T}}\mathbf{x}_{\mathbf{l}}^{*}\right). \tag{3}$$

2.2 Determination of the investment characteristics – 'moving' concept

In order to reflect the dynamics of the development in the capital market, the return and risk characteristics are proposed in the 'moving' form, i.e. using a moving average. Let *T* defines the number of equally long time periods with *K* observations of returns. Then the (expected) return of the *m*-th open-end mutual fund in the *t*-th period can be calculated as a mean

$$r_{mt} = \frac{1}{K}\sum_{k=1}^{K} r_{mtk} \qquad m = 1,2,...,M;\, t = 1,2,...,T, \tag{4}$$

where $r_{mtk}, m = 1,2,...,M, t = 1,2,...,T, k = 1,2,...K,$ is *k*-th observation of return of the *m*-th open-end mutual fund in *t*-th period. The risk of the *m*-th open-end mutual fund in the *t*-th subperiod is computed as absolute negative deviation

$$l_{mt} = \frac{1}{K_{mt}^{-}}\sum_{k=1}^{K_{mt}^{-}} (r_{mt} - r_{mtk}) \qquad m = 1,2,...,M;\, t = 1,2,...,T, \tag{5}$$

where $K_{mt}^{-}, m = 1,2,...,M, t = 1,2,...,T,$ indicates the number of cases where the particular return is less than the mean for the *m*-th open-end mutual fund in the *t*-th subperiod. The difference between the beginning, or end, of two consecutive periods is constant during the entire historical period. Neighbouring subperiods overlap between the beginning of one period and the end of the previous one. The return, or risk, of the *m*-th open-end mutual fund can be calculated as the moving mean, or moving absolute negative deviation as follows

$$r_m = \frac{1}{T}\sum_{t=1}^{T} r_{mt}, \text{ or } \quad l_m = \frac{1}{T}\sum_{t=1}^{T} l_{mt} \qquad m = 1,2,...,M. \tag{6}$$

The cost is represented by the entry fee, which is expressed as a percentage of the amount invested. Other fees are reflected directly in the price, or return of the open-end mutual fund. The entry fee changes very little over time, often remaining the same for years. The fee is therefore seen as stable. The entry fee c_m of the *m*-th open-end mutual fund is taken at the current level when the investment made.

Model (1) can be considered as a dynamized form of the Markowitz model due to the return and risk expressed by the 'moving' concept. The model is thus closer to capital market conditions. A minor drawback may be the absence of the possibility to express the influence of returns on each other. However, this is not very significant in an environment where returns do not affect each other much or most of them move in the same direction. The disadvantage is then offset the benefit of the linearity of the risk function, whose global extreme is easier to find. In addition, positive deviations are not penalised. Aggregate weighted sum function allows the simultaneous reflection of the investor's preferences about the expected characteristics of the investment portfolio according to his attitude to risk, or the 'return-risk' profile. The elimination of the thresholds used in Markowitz model supports the applicability of the model (1) in investment practice.

2.3 Evaluation of changes in investment behavior

The most appropriate investment portfolio is made through model (1). Subsequently, the investment is managed in the spirit of the investment policy style. Sudden extreme situations, such as financial crisis, pandemic, terrorist attack, or war conflict, can trigger a wave of sell-offs. Of course, fundamental changes can also be triggered by positive events. An attentive investor reacts to the situation, often deciding to restructure the portfolio.

In order to re-optimize the portfolio, the mathematical model (1) is updated with the data collected from the time period of the "life" of the investment. The observed historical period is then moved by this time to the present. The number and length of subperiods remain the same. Excessive capital market development prompts a change in investor preferences, which is reflected through the weights in the aggregate objective function of model (1).

In the updated model (1), the determination of return and risk is similar, but based on a different time period, as mentioned above. The shift in time towards the present may be reflected in different values of entry fees. However, as mentioned earlier, especially over shorter or medium time horizon, fee change very little or not at all. The current entry fee is of course very easy to obtained. However, the portfolio restructuring may not involve the sale/purchase of unit certificates of open-end mutual funds, but 'only' their exchange at the current prices. Then, the entire entry fee of the newly included fund in the portfolio is not paid. If the entry fee of the newly included fund is less than or equal to the existing fund, no fee is payable. Otherwise, a positive difference is charged. So how to determine this fee for each open-end mutual fund at the relevant time? The following (approximate) procedure is proposed. Of course, the current value of the entry fee is considered. This value is relative to the cost of the current portfolio (with fund shares according to actual market prices of the unit certificates) ready for re-optimization. If the current entry fee is less than or equal to the current portfolio cost, the fund enters the restructuring process with a zero (expected) entry fee. If the reverse is the case, the fee is estimated as the difference between the fund's current fee and the cost of the current portfolio. In this way, the 'cost' position of the open-end mutual fund in the re-optimization process is determined, reflecting the potential (expected, approximate) payment for the transfer of capital between a particular fund and others. Let us refer to this cost for *m*-th open-end mutual fund as the revised entry fee computed through the following formula

$$c_m^{rev} = \max\left\{0, c_m^a - \mathbf{c}^{\mathbf{a}^{\mathrm{T}}} \mathbf{x}^{\mathbf{a}}\right\} \qquad m = 1, 2, ..., M, \tag{7}$$

where the vector $\mathbf{x}^{\mathbf{a}} = (x_1^a, x_2^a, ..., x_M^a)^T$ represents the current shares of the open-end mutual funds in the portfolio (according to the actual market prices) and $\mathbf{c}^{\mathbf{a}^{\mathrm{T}}} = (c_1^a, c_2^a, ..., c_M^a)$ contains the actual entry fee. Then c_m^a, or $\mathbf{c}^{\mathbf{a}^{\mathrm{T}}} \mathbf{x}^{\mathbf{a}}$ denotes actual entry fee of *m*-th fund, or actual portfolio cost at the crucial moment of re-optimization. The developed formula (7) can be adapted to the actual composition of the portfolio or its composition requirements.

The effect of portfolio restructuring can be evaluated after adequate time, in particular by comparing the performance of the original portfolio with its revised version. Other characteristics, or their expected values, can be monitored. We can now see how the often hasty decision under the weight of unexpected events has affected the investment.

3. (Re-)optimization of the portfolio of the open-end mutual fund

The next section presents the central part of the paper, an empirical analysis of behavioural change and its effects due to the outbreak of the viral disease COVID-19 pandemic. For this purpose, the investment decision making procedure headed by the adapted model is applied.

3.1 (Revised) investment strategy and open-end mutual fund pre-selection

The choice of investment strategy (policy) is the basis of the investment process. The mission of this paper is certainly to get as close as possible to investment practice, so one of the most common (according to my personal experiences and previous research) investment cases is simulated. This is an investor that is more likely to be in the early of slightly advanced stages of working age. His awareness signals him that he should think about at least partial financial security in retirement, because in today’s hardly sustainable pension system (not only in the Czech Republic), the state pension and the sufficiency of its amount cannot be relied on too much. The purpose of the investment can be generalised to an attempt to value the available funds for use in the more distant future. A long-term investment horizon tends to evoke passive portfolio management. However, this does not mean that the investor cannot monitor, evaluate and, if necessary, revise the investment over time. This type of investment does not require significant liquidity of investment instruments. Often, the investment can be relatively small, and can be made on a regular basis.

The aforementioned investment features favour the choice of open-end mutual funds, through which you can invest in various investment instruments (stocks, bonds, etc.) around the world. One of the largest providers in the Czech market of the collective investment is Česká spořitelna, whose funds were selected for the empirical analysis. These are five bond, three equity, five mixed and one real estate funds, which are arranged in this order in Table 1.

Let’s take a closer look at the investment story. As mentioned, this is a longer-term investment that was made in early 2019, after a short period of price declines in the capital markets. Thus, an investor with available funds is taking advantage of locally lower prices to invest. Open-end mutual funds are great choice, and investing in them is very easy. However, this fact is ‘redeemed’ by the fees that burden the investment. Often the investor only knows about the entry fee, which is paid on the amount invested. However, the investment is burdened with a series of other fees (for license, audit, management, etc.) that are not so visible because they are reflected directly in the price of the unit certificates. It makes sense, therefore, that the cost aspect is represented only by the entry fee. The characteristics of return, or risk, absorb the other fees. These three characteristics associated with open-end mutual funds are absolutely essential for the investor. Other, potentially less important characteristics, such as currency, market location, liquidity, etc., can be included in the decision-making process during the pre-selection of suitable candidates for investment. In the case of greater importance, it is not a problem to explicitly integrate these criteria into the proposed model (1). A portfolio is a compilation of several investment instruments, here, unit certificates issued by open-end mutual fund. It is thus natural that, in the spirit of investment policy, an investor may have certain input requirements for the structure of the portfolio. Especially for a less experienced investor, a diverse portfolio would be rather detrimental. There is therefore a minimum and maximum level of the proportion of one open-ended mutual fund in the portfolio. Based on investment experiences with these funds, a portfolio of three to six funds seems practical. The minimum, or maximum share is then set at 15%, or 45%.

The return and risk of the selected open-end mutual funds are calculated, as mean and absolute negative deviation of returns, from the prices downloaded from the archive of Investment Center (2022). In order to plausibly capture the long-term development of the observed characteristics, the historical period from 2011 to 2018 has been chosen. To capture instable dynamics over a longer time horizon, this period is divided into four still sufficiently long representative overlapping five-year subperiods, i.e. 2011−15, 2012−16, 2013−17, 2014−18. In each subperiod, monthly returns are calculated for each open-end mutual fund, from which risk is then computed using formulas (4) and (5). Subsequently, the return, or risk of each fund is determined as moving mean, or moving absolute negative deviation (6). The entry fee is statically set at the current level of the investment realization, i.e. at the beginning of 2019. This unchanged data over the last years is downloaded for each fund on the Investment Center website (2022). All data can be found in Table 1.

Table 1: Return, risk and cost of open-end mutual fund (in %)

Open-end mutual fund	01/2011−12/2018			04/2012−03/2020		
	Return	Risk	Cost	Return	Risk	Cost
Sporoinvest	0.007	0.104	0.3	-0.009	0.110	0
Sporobond	0.218	0.591	1	0.119	0.526	0.048
Trendbond	0.069	1.443	1	-0.072	1.394	0.048
Corporate bonds	0.126	0.995	1	0.094	0.878	0.048
High Yield bond	0.292	0.928	1	0.211	0.798	0.048
Sporotrend	-0.096	3.733	3	0.067	3.431	2.048
Global Stocks	0.850	2.793	3	0.635	2.574	2.048
Top Stocks	1.078	3.242	3	0.719	3.646	2.048
Controlled returns	-0.034	0.171	1	-0.061	0.159	0.048
Equity Mix	0.458	2.283	3	0.303	2.590	2.048
Dynamic Mix	0.337	1.637	1.5	0.204	1.810	0.548
Balanced Mix	0.280	1.037	1.5	0.182	1.125	0.548
Conservative Mix	0.144	0.518	1	0.089	0.541	0.048
Real estate	0.235	0.219	1.5	0.239	0.204	0.548

Despite long-term goals, the rapid spread of a deadly viral contagion can change long-term goals quickly. The unending fear sends market prices steeply down in February and especially in March 2020. Investor thus decides to revise the portfolio to minimize potentially impending losses. Data from the beginning of the investment until the outbreak of the pandemic will be used for this re-optimization. Again, an eight-year period is used, which should be representative of development in the longer term. However, it is now enriched with the currently known data from the beginning of the original investment after its revision, i.e. the period 1/2019-03/2020. The eight-year period is then again divided into four five-year subperiods shifted by one year and three months to the present, i.e. 04/2012−03/2017, 04/2013−03/2018, 04/2014−03/2019 and 04/2015−03/2020, from which moving return and risk are again calculated according to relations (4)−(6). The data, including the recalculated cost in the form (7), are located in Table 1.

3.2 Portfolio (re)optimization

First, the importance of each characteristic for the investor is expressed. In the context of a longer-term investment strategy formed in the slightly more turbulent times of the turn of 2018/2019, risk is perceived slightly more strongly. However, the importance of return lags only slightly behind. Cost, after all, is significantly less important to the investor. Upon reflection, such a perceptive investor sets the weights (e.g. through the subjective scoring by a user-friendly scoring method) at the levels which can be seen in the following initial model formulated by (1)

$$\begin{aligned} &\max \quad 0.40\frac{\mathbf{r}^{\mathrm{T}}\mathbf{x}-0.025}{0.894-0.025}+0.45\frac{2.918-\mathbf{l}^{\mathrm{T}}\mathbf{x}}{2.918-0.148}+0.15\frac{3-\mathbf{c}^{\mathrm{T}}\mathbf{x}}{3-0.685} \\ &\mathbf{e}^{\mathrm{T}}\mathbf{x}=1 \\ &0.15\mathbf{y}\le \mathbf{x}\le 0.45\mathbf{y} \\ &\mathbf{x}\ge \mathbf{0} \\ &\mathbf{y}\in\{0,1\}, \end{aligned} \tag{8}$$

where $\mathbf{x}=(x_1,x_2,...,x_{14})^T$ is a vector of variables $x_i, i=1,2,...,14,$ representing the share of the *i*-th open-end mutual fund, sorted by the first columns of Table 1. Vectors $\mathbf{r}^{\mathrm{T}}=(r_1,r_2,...,r_{14}),\ \mathbf{l}^{\mathrm{T}}=(l_1,l_2,...,l_{14}),$ and $\mathbf{c}^{\mathrm{T}}=(c_1,c_2,...,c_{14})$ include the return r_i, risk l_i and cost $c_i, i=1,2,...,14,$ of the *i*-th open-end mutual fund. The vector $\mathbf{e}^{\mathrm{T}}$ contains of fourteen ones. The binary variable $y_i, i=1,2,...,14,$ situated in the vector $\mathbf{y}=(y_1,y_2,...,y_{14})^T$, indicates (non-)presence of the *i*-th open-end mutual fund in the portfolio. These variables are used to express the requirement to limit the share of one fund in the portfolio. All conditions form a set of feasible solutions *X*. The extreme values of the portfolio characteristics are determined through (2) and (3).

The optimal solution of this linear mixed binary mathematical programming model is found through a branch and bounds method implemented in Lingo optimization software. The portfolio composition is as follows: 40% *Sporoinvest*, 15% *Sporobond* and 45% *Real estate fund*. Its characteristics are: return 0.141%, risk 0.229% and cost 0.945%. Since risk has the highest weight, it is not surprising that the risk is relatively low. The choice of a lower risk portfolio is also supported by the non-zero solid weight of the cost criterion. Indeed, it can be observed that lower risk funds also have lower cost. And in the field of collective investment, it is also true, and the data generally show this, that the less potential risk we require, the lower the return will be. The composition of this portfolio is proof of that. The fund with the lowest (Sporoinvest) and third lowest (Real estate fund) risk plays the main role. The fund with the second-lowest risk, named Fund of controlled returns, is not included because of its negative return. The importance of the risk criterion would have to be significantly higher for this fund to be included in the portfolio. As expected, equity funds are not included because they have a “higher” return-risk profile. As the return weighting increases (from 0.5), equity funds start to gain ground with gradual dominance. The usual ‘higher return-higher risk’ law of the capital market has long been defied by the Sporotrend equity fund, which shows a loss at high risk level. This fund therefore clearly has no chance of participating in the portfolio under the specified conditions.

With the advent of the COVID-19 pandemic, markets are beginning to fluctuate significantly. The initial shock of an imminent global killer disease is followed by a wave of sell-offs in March and partly in April 2020. The increasing negative trend in mutual fund prices will force investors to change their investment strategy. It revises portfolio composition under the weight of new, current data. The investor's preferences also undergo changes. The fear of negative development makes the investor more risk averse. The weights of the criteria are then estimated (e.g. by scoring method once again) as follows: 0.35 for return, 0.5 for risk and 0.15 for cost. With the new data from the announced period 04/2012-03/2020, the mathematical model (1) is solved in the following form

$$\begin{aligned}
\max \quad & 0.35\frac{\mathbf{r}^{\mathbf{T}}\mathbf{x}-0.007}{0.623-0.007}+0.50\frac{3.059-\mathbf{l}^{\mathbf{T}}\mathbf{x}}{3.059-0.143}+0.15\frac{2.048-\mathbf{c}^{\mathbf{rev}^{\mathbf{T}}}\mathbf{x}}{2.048-0.027} \\
& \mathbf{e}^{\mathbf{T}}\mathbf{x}=1 \\
& 0.15\mathbf{y}\le\mathbf{x}\le 0.45\mathbf{y} \\
& \mathbf{x}\ge\mathbf{0} \\
& \mathbf{y}\in\{0,1\},
\end{aligned} \tag{9}$$

where $\mathbf{c}^{\mathbf{rev}^{\mathbf{T}}}=(c_1^{rev},c_2^{rev},...,c_M^{rev})$ is a vector containing the actualized cost according to the formula (7). The cost values are lower because there is an exchange of capital between funds. The pandemic sell-offs have clearly had an impact on the return characteristic. The re-optimized portfolio takes the following form: 15% *Sporoinvest*, 40% *High Yield bond* and 45% *Real Estate* fund. The expected values of the characteristics have been changed to the following form: return 0.191%, risk 0.427% and cost 0.266%. Under the risk averse perspective, the values of the investment characteristics are probably surprising. In fact, they are higher than for the initial portfolio. This is due to the favourable return-risk profile of the High Yield bond open-end mutual fund, which has newly entered the portfolio. While the fund's return is lower, as is ultimately the case with other funds, it also has significantly lower risk, which is generally unique in the context of other funds. However, as risk aversion intensifies, the prominent role of the low risk Sporoinvest and Real estate funds will stabilize. The solid return of High Yield bond fund will no longer be a factor and the fund will drop out of the portfolio. Then both return and risk will begin to decline.

3.3 What does a pandemic change in investment behaviour bring?

The representative evaluation factor of the portfolio review is a performance of the investment. However, a history of one, or even three, years is not fully indicative of the long-term investment horizon. Nevertheless, it can provide interesting and valid information. The performance of the original portfolio constructed in early 2019 is 2.57%, or 2.86% through 03/2020, or 03/2022. It is therefore evident that after the pandemic struck, the portfolio is no longer making much profit, which is mainly due to the negative price development of the Sporoinvest and especially Sporobond fund, contrary to expectations. The re-optimised portfolio is much better off. Over the course of the two pandemic years, it has earned almost 5%, thanks mainly to the High Yield bond fund. The investment has earned 7.85% overall since the beginning of 2019. Even if the portfolio restructuring had been done in a more risk averse manner, the presence of the Fund of controlled returns, for its low risk, instead of the Sporobond would have provided a slightly higher return.

In the case of a more risk-averse policy, restructuring the portfolio, the equity component could yield returns in the tens of percentages over two pandemic years. The ideal decision under the specified conditions would be a portfolio composed only of equity titles with a two pandemic year performance of 56.564%. On the other hand, re-optimization could turn out badly. The worst-case decision could result in a loss of 14.261%, which would be mainly due to the Trendbond fund with the highest possible weight of 0.45. The price of Trendbond unit certificate has fallen by approximately 25% from the pandemic outbreak to the March 2022 reporting period. However, this decision would have been unwise, as the negative price development of this and other funds was expected based on historical data. Thus, it can be concluded that re-optimising the portfolio based on rational expectations from historical development yields a higher real return for the investor over the evaluating two-year period, which is certainly a positive signal for long-term investment.

4. Conclusion

This paper analyses the impact of the COVID-19 pandemic on investment behaviour. The increasingly popular (Czech) market with open-end mutual funds is used for this empirical analysis. We have seen in the past that unexpected negative events (terrorist attack, natural disaster, disease pandemic, etc.) can have a significant impact on investor behaviour. This was most notably the case during the pandemic that triggered a wave of sell-offs across global stock markets. This article simulates one of the most common cases of investment practice – the long-term investor who, like many others, resorts to revising his investment portfolio when unexpectedly negative developments occur. To this end, a re-optimization decision procedure is proposed based on the developed model called mixed moving mean-absolute negative deviation-entry fee model. It uses a 'moving' concept, using moving averages, that is designed to uniquely consider a typical price dynamic.

Has the spate of deadly viral outbreaks left any marks on the composition of the portfolio? Yes, the revised portfolio, created on the basis of an amended investment strategy reflecting current development, has a different composition. The rational decision, supported by historical data, seems to be positive, as the portfolio shows a higher return over the two-year evaluation period than the original one. Although the decision is hasty, implemented in an extreme situation, at least in the short term it turns out to be correct. On the other hand, I am aware that an investor can make completely irrational decisions in such tense moments. The proposed model successfully attempts to counteract this phenomenon, as evidenced by the higher appreciation of the revised portfolios.

Where could follow-up research go? A change in investor preferences might not only be reflected in the weights of the criteria, but also in some special additional requirements for investment portfolio (e.g. minimum/maximum share of funds, location of markets, types of funds, etc.), which would make the decision more complex if necessary. Different weights of subperiods in the moving average could distinguish different degrees of influence of historical subperiods, which could refine the formation of expectations.

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EVA measure dynamic decomposition of metallurgy applied research company

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Abstract

The performance analysis results create significant information for the successful management of companies. The static influence often applied is not stable. Therefore, the dynamic analysis can be helpful for long-term strategic management. The paper proposed a method of influential dynamic analysis using the variance analysis methodology. The absolute and relative performance measures of economic value added are investigated, and the pyramid decomposition design is applied. The usefulness of the dynamic company analysis was verified. In the example, the extreme influence factors were the same, ranking of the influential factors was different for relative and absolute performance measures. The most important financial ratios cover the essential characteristics of financial performance, particularly profitability, leverage and liquidity. It was verified that the pyramid decomposition system could influence the analysis results. So, to obtain stable results, the robustness of the influential analysis should be investigated.

Keywords Performance measure, Economic value added, Dynamic decomposition, Variance analysis, Applied research, Metallurgy sector

JEL Classification: C5, G3, L2, L25, L61, M1, M2, O3

1. Introduction

Measuring a firm's performance is one of the critical problems not only on the macroeconomics level management but also on the management level of individual firms. Approaches for measuring a firm's performance have passed through evolution and reflect both technical-economic type of economy, information possibilities and the knowledge of economic systems management. Among performance indicators can be found traditional group based on accounting profitability measures such as ROE, ROA, ROC, ROI, and RONA and measures based on financial cash flow such as CFROI, NPV, and CROGA. A relatively new group of measures is based on the microeconomic theory of the economic profit category, which is the profit level after deduction of an alternative cost of capital. In this case, market and accounting data are combined, and measures of economic value added EVA and market value added MVA can be included here.

The EVA measure is based on the concept of economic profit, which has been a part of the financial theory for a long time. But only recently has this measure been applied in practice. More and more firms, both the market and transitive countries, adopt this measure as a benchmark for planning and managing a firm's performance. The EVA is a measure of a firm's ability to create wealth for its shareholders. Economic value added EVA and market value added MVA are measures of a firm's performance, which have been designed to motivate managers on shareholder value increase. Stern Stewart Company popularised this approach in the USA, where this method has been implemented into the management system of many firms. There have been written a lot of papers regarding this topic, e.g. see Rappaport (1986), Stewart

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(1991), Grant (1997), Young et al. (2000), O'Byrne (1996), Damodaran (2002), Dluhošová (2003), Athanassakos (2007), Gupta et al. (2016), Iazzolino et al. (2014).

Traditional performance measure analysis is focused on a static approach. However, the results are not stable and fluctuate between years. So, it is not easy to determine fundamental influence factors. The problem overcomes a dynamic influence analysis, which can be performed e. g. by a variance analysis method. A valuable tool for more profound analysis is a pyramid decomposition method allowing to analyse of various influence factors mutually connected precisely.

Performance driving factors are not unique but specific for various companies and sectors. Companies dealing with applied research are exposed to an innovative cycle and are in an economic behaviour different from production and trade companies. Therefore, an analysis of companies of the type is desirable.

The paper's objective is to carry out the dynamic performance analysis of a metallurgy applied research company based on EVA measures for the period from 2016 to 2020. The absolute and relative influences are investigated.

The analysed company has 300 employees in six profit units. The activity is focused on a unique metallurgy production and information and automatisation technique, including applied research and licence policies. The first part is devoted to the performance EVA measure calculation and methodological approaches; subsequently, the dynamic analysis procedure is described, and input data are introduced.

2. Methodology and input data

The methodological part includes a description of EVA measure conceptions. Furthermore, dynamic analysis based on variance analysis is described. Finally, the development of the input financial ratios, including the absolute and relative EVA measures, are presented.

2.1 Calculation of Economic value added (EVA)

The EVA is derived from the basic rule that a firm has to create at least such value as has been invested. A cost of capital or internal rate of return concerns both equity and debt. So the debt holders have the right to receive their interest and shareholders' dividends, i.e. to cover an adequate rate of return, which could compensate for their risk. The EVA is how shareholders measure their profit after covering the alternative cost of capital.

The general concept of EVA, as a measure of financial performance, expresses the difference between profit and cost of capital, which reflects a minimal rate of return of capital invested (equity and debt). Data set availability is the way of calculating the cost of capital to determine the method. Moreover, it is also essential if an absolute or a relative value is calculated. Broadly speaking, there are two basic concepts of calculation: the operating profit conception and the value spread conception.

EVA calculation based on operating profit is defined as follows,

$$EVA = NOPAT - WACC\,. \tag{1}$$

It implies from the definition that basic elements for EVA calculation are net operating profit after taxation $NOPAT$ value of total capital invested C and a weighted cost of capital $WACC$.

The $NOPAT$ and the value of total capital invested C (in book value) are adjusted to precisely reflect return and capital. There are many modifications of a $NOPAT$ measure for the purpose of EVA calculation. It is necessary to point out that an operating profit is by authors understood differently, see e. g. Rappaport (1986) and Stewart (1991).

A positive value of an EVA is achieved when $NOPAT$ measure is higher than capital requirements. This difference represents the value added to the shareholder's wealth in a given period. On the other hand, a negative value EVA reflects a decline in shareholder wealth because the firm cannot achieve the minimum return required by the providers of capital for its financing.

Other versions of EVA calculation can be expressed using the so-called value spread. Value spread reflects economic profit, which can be calculated as a difference between achieved profitability and the cost of capital.

An EVA calculation based on value spread can be formulated as follows,

$$EVA = \left(ROC - WACC\right) \cdot C, \tag{2}$$

where ROC is the return on capital invested. Equitation (2) explains that an EVA depends primarily on $ROC - WACC$ spread, i.e. residual return on capital.

The narrow spread approach of EVA can be calculated by the formula,

$$EVA = \left(ROE - R_E\right) \cdot E, \tag{3}$$

where ROE is the return on equity, and R_E is the market cost of equity. In this case, only ROE is the input parameter. It is vital for the owners the $ROE - R_E$ spread to be as large as possible or at least positive. Only in this case, investment to the firm brings more than an alternative investment.

Relative EVA expression,

$$EVA = \left(ROE - R_E\right) \tag{4}$$

In this situation, the value of an EVA is independent of equity level, and the relative firm's performance should be measured.

2.2 Dynamic decomposition based on the variance analysis

The static deviation analysis is focused on the change of one period. The interesting information concern how particular financial ratios (factors) impact an explained deviation in more periods, viz Dluhošová et al. (2015), Dluhošová (2021), Zmeškal (2004), Zmeškal et al. (2013). It is possible to find by the variance analysis or by an expected quadratic deviation. The procedure is demonstrated for a multiplicative relation for three particular ratios thus $x = a_1 \cdot a_2 \cdot a_3$. Since the variance can be applied for a linear function, a Taylors expansion approximation is used, $\Delta x = \frac{\partial x(\cdot)}{\partial a_1}\Delta a_1 + \frac{\partial x(\cdot)}{\partial a_2}\Delta a_2 + \frac{\partial x(\cdot)}{\partial a_3}\Delta a_3$. After derivation, it is valid that $\Delta x = a_2 \cdot a_3 \cdot \Delta a_1 + a_1 \cdot a_3 \cdot \Delta a_2 + a_1 \cdot a_2 \cdot \Delta a_3$. After substitution for derivation thru parameters α, the deviation can be written as follows $\Delta x = \alpha_1 \cdot \Delta a_1 + \alpha_2 \cdot \Delta a_2 + \alpha_3 \cdot \Delta a_3$. Having been expressed a particular deviation simultaneously with parameter due to z, then $\Delta x = z_1 + z_2 + z_3$. Supposing a knowledge of ratios time-series (vectors) $\Delta\vec{x} = \left[\Delta x_1; \Delta x_2; \ldots \Delta x_N\right]$, $\vec{z}_i = \left[z_{i1}; z_{i2}; \ldots z_{iN}\right]$, then an expected value $E\left(\vec{z}_i\right) = \frac{1}{N}\sum_{n=1}^{N} z_{in}$, covariances $C_{ij} = \text{cov}\left(\vec{z}_i; \vec{z}_j\right)$ and correlation $\text{R}_{ij} = \text{cor}\left(\vec{z}_i; \vec{z}_j\right)$ can be calculated. On this basis, the variance is formulated in the following way $\text{var}(\Delta\vec{x}) = \sum_{i=1}^{3}\sum_{j=1}^{3}\text{cov}\left(\vec{z}_i; \vec{z}_j\right)$. A ratio (factor) contribution to variance is determined in this way $s\left(\vec{z}_i\right) = \sum_{j=1}^{3}\text{cov}\left(\vec{z}_i; \vec{z}_j\right)$. Finally, a searched impact of the particular ratios is stated as a share from a variance as follows $w\left(\vec{z}_i\right) = \frac{s\left(\vec{z}_i\right)}{\text{var}(\Delta\vec{x})}$. The introduced procedure is easy to generalise for more ratios $s(\vec{z}_i) = \sum_{j=1}^{N} \text{cov}(\vec{z}_i; \vec{z}_j)$ or other mathematical operations (+, -, /).

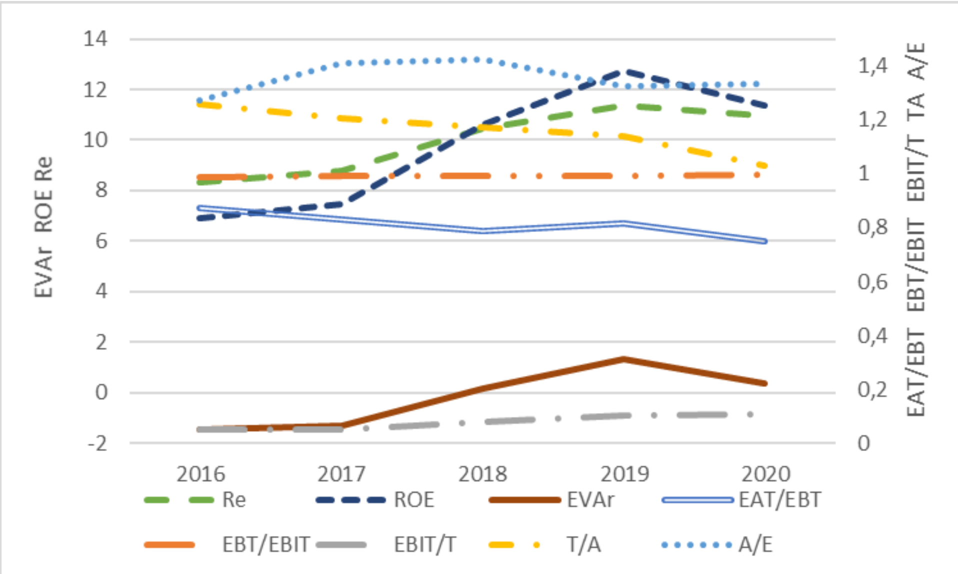
2.3 Input data

The EVA financial performance measure is decomposed into several financial ratios. The development of ratios is presented in Table 1 and Graph 1. The meaning of the symbols is the following EAT earnings after tax, EBT earnings before tax, $EBIT$ earnings before interest and tax, S sales, A assets, E equity, R_E return on equity cost, ROE return on equity, EVA_r and relative EVA.

Table 1: Input data of financial ratios

ratio	unit	2016	2017	2018	2019	2020
EAT/EBT		0,8739	0,8319	0,7889	0,8158	0,7515
EBT/EBIT		0,9881	0,9925	0,9933	0,9917	0,9948
EBIT/S		0,0497	0,0532	0,0811	0,1045	0,1102
S/A		1,2586	1,2071	1,1746	1,1368	1,0319
A/E		1,2736	1,4113	1,4248	1,3249	1,3343
R_E	%	8,3372	8,7995	10,4736	11,3801	10,9620
ROE	%	6,89	7,48	10,63	12,73	11,34
EVA_r	%	-1,4507	-1,3159	0,1557	1,3492	0,3817
E	thousund CZK	316863	342494	375397	401505	407760
EVA	thousund CZK	-4596,62	-4506,78	584,33	5417,22	1556,35

Graph 1: Input data of financial ratios development (period 2016-2020)



It is apparent that EVA measure shows a growing trend even if the negative value is reached in the 2016 and 2017 years. Therefore, in these years, the company could not create wealth for company owners. Just in 2016, the result is the lowest, EVA is – 4596,62 thousand CZK. The ROE value is the lowest in the year as well. Next year ROE starts growing but simultaneously R_E and EVA is better even if a negative value – 4506,78 thousand CZK. A breakpoint was apparent in 2018, and the company reached a positive value of EVA ve výši 584,33 thousand CZK. The next year 2019, all ratios demonstrated a positive trend, ROE was close to 12,73 %, which is the highest value in the tracked period. The R_E are of 1,349 % lowest and are of 11,38 % value. In the case of 2020, the EVA is lower however is positive, creating owners' wealth.

3. Application of dynamic decomposition

An application and verification of dynamic influence analysis of EVA equity based on pyramid decomposition are performed. The narrow spread in absolute and relative versions is applied due to (3) and (4). The cost of capital is computed on the construction model basis; see Ministry of Industry and Trade, Czech Republic, www.mpo.cz.

Dynamic analysis is carried out for absolute and relative EVA pyramidal decomposition. Dynamic analysis due to the methodology of section 2.2 is applied.

3.1 Absolute EVA decomposition

The decomposition stems from an absolute EVA formulation $EVA = (ROE - Re) \cdot E$. Applying the decomposition of ROE, the following equation is determined,

$$EVA = (EAT/EBT) \cdot (EBT/EBIT) \cdot (EBIT/T) \cdot (T/A) \cdot (A/E) \cdot E - R_E \cdot E,$$

The absolute EVA change is expressed by the following equation,

$$\Delta EVA = \frac{\partial EVA}{\partial (EAT/EBT)} \Delta (EAT/EBT) + \frac{\partial EVA}{\partial (EBT/EBIT)} \Delta (EBT/EBIT)$$

$$+ \frac{\partial EVA}{\partial (EBIT/T)} \Delta (EBIT/T) + \frac{\partial EVA}{\partial (T/A)} \Delta (T/A)$$

$$+ \frac{\partial EVA}{\partial (A/E)} \Delta (A/E) + \frac{\partial EVA}{\partial (E)} \Delta (E) - \frac{\partial EVA}{\partial (R_E)} \Delta R_E$$

and derivations substituted to equations a are as follows,

$$\frac{\partial EVA}{\partial (EAT/EBT)} = (EBT/EBIT) \cdot (EBIT/T) \cdot (T/A) \cdot (A/E) \cdot E$$

$$\frac{\partial EVA}{\partial (EBT/EBIT)} = (EAT/EBT) \cdot (EBIT/T) \cdot (T/A) \cdot (A/E) \cdot E$$

$$\frac{\partial EVA}{\partial (EBIT/T)} = (EAT/EBT) \cdot (EBT/EBIT) \cdot (T/A) \cdot (A/E) \cdot E$$

$$\frac{\partial EVA}{\partial (T/A)} = (EAT/EBT) \cdot (EBT/EBIT) \cdot (EBIT/T) \cdot (A/E) \cdot E$$

$$\frac{\partial EVA}{\partial (A/E)} \Delta (A/E) = (EAT/EBT) \cdot (EBT/EBIT) \cdot (EBIT/T) \cdot (T/A) \cdot E$$

$$\frac{\partial EVA}{\partial (E)} \Delta (E) = (EAT/EBT) \cdot (EBT/EBIT) \cdot (EBIT/T) \cdot (T/A) \cdot (A/E) - R_E$$

$$\frac{\partial EVA}{\partial (R_E)} = E.$$

3.2 Relative EVA decomposition

Furthermore, the dynamic decomposition for relative EVA is performed due to $EVA = \left(ROE - R_E\right)$. Analogically to the previous section for the decomposition of ROE, the following equation is stated,

$$EVA = \left(EAT/EBT\right)\cdot\left(EBT/EBIT\right)\cdot\left(EBIT/T\right)\cdot\left(T/A\right)\cdot\left(A/E\right) - R_E\,,$$

The relative EVA change is expressed by the following equation,

$$\Delta EVA = \frac{\partial EVA}{\partial\left(EAT/EBT\right)}\Delta\left(EAT/EBT\right) + \frac{\partial EVA}{\partial\left(EBT/EBIT\right)}\Delta\left(EBT/EBIT\right)$$

$$+\frac{\partial EVA}{\partial\left(EBIT/T\right)}\Delta\left(EBIT/T\right) + \frac{\partial EVA}{\partial\left(T/A\right)}\Delta\left(T/A\right)$$

$$+\frac{\partial EVA}{\partial\left(A/E\right)}\Delta\left(A/E\right) - \frac{\partial EVA}{\partial\left(R_E\right)}\Delta R_E$$

and derivation parts are the following,

$$\frac{\partial EVA}{\partial\left(EAT/EBT\right)} = \left(EBT/EBIT\right)\cdot\left(EBIT/T\right)\cdot\left(T/A\right)\cdot\left(A/E\right)\text{Ad}$$

$$\frac{\partial EVA}{\partial\left(EBT/EBIT\right)} = \left(EBIT/T\right)\cdot\left(T/A\right)\cdot\left(A/E\right)$$

$$\frac{\partial EVA}{\partial\left(EBIT/T\right)} = \left(EAT/EBT\right)\cdot\left(EBT/EBIT\right)\cdot\left(T/A\right)\cdot\left(A/E\right)$$

$$\frac{\partial EVA}{\partial\left(T/A\right)} = \left(EAT/EBT\right)\cdot\left(EBT/EBIT\right)\cdot\left(EBIT/T\right)\cdot\left(A/E\right)$$

$$\frac{\partial EVA}{\partial\left(A/E\right)}\Delta\left(A/E\right) = \left(EAT/EBT\right)\cdot\left(EBT/EBIT\right)\cdot\left(EBIT/T\right)\cdot\left(T/A\right)$$

and

$$\frac{\partial EVA}{\partial\left(R_E\right)} = -1\,.$$

Table 2 presents the computed results due to the methodology introduced. The correlation matrix of approximated variables is in Table 3.

Table 2: Computed parameters

Items		**EAT/EBT**	**EBT/EBIT**	**EBIT/S**	**S/A**	**A/E**	**E**	**R_E**
Deviation	Δa_{in}	- 0,04202	0,00433	0,00346	-0,0515	0,1377	25631	0,0046
		- 0,04305	0,00084	0,02785	-0,0325	0,0135	32903	0,0167
		0,02697	- 0,00161	0,02341	-0,0378	-0,0999	26108	0,0091
		- 0,06435	0,00315	0,00573	-0,1049	0,0095	6255	- 0,0042
Parameter	α_{in}	24969	22083,2	438618,6	17337,2	17133,3	-0,01451	-316863
		30810	25825,7	481707,4	21234,0	18161,7	-0,01316	-342494
		50582	40171,0	492263,1	33972,0	28005,5	0,00156	-375397
		62647	51537,3	489223,9	44960,4	38576,3	0,01349	-401505
Approximated variable	z_{in}	24969	22083,2	438618,6	17337,2	17133,3	-0,01451	-316863
		30810	25825,7	481707,4	21234,0	18161,7	-0,01316	-342494
		50582	40171,0	492263,1	33972,0	28005,5	0,00156	-375397
		62647	51537,3	489223,9	44960,4	38576,3	0,01349	-401505

Table 3: Correlation matrix

R	**EAT/EBT**	**EBT/EBIT**	**EBIT/S**	**S/A**	**A/E**	**E**	R_E
EAT/EBT	1	-0,9293	0,5495	0,7608	-0,5589	-0,0991	-0,6508
EBT/EBIT	-0,9293	1	-0,8083	-0,6759	0,7412	0,0335	0,7702
EBIT/S	0,5495	-0,8083	1	0,4914	-0,6657	-0,1424	-0,8534
S/A	0,7608	-0,6759	0,4914	1	-0,0066	-0,7209	-0,8518
A/E	-0,5589	0,7412	-0,6657	-0,0066	1	-0,6015	0,2824
E	-0,0991	0,0335	-0,1424	-0,7209	-0,6015	1	-0,5956
R_E	-0,6508	0,7702	-0,8534	-0,8518	0,2824	0,5956	1

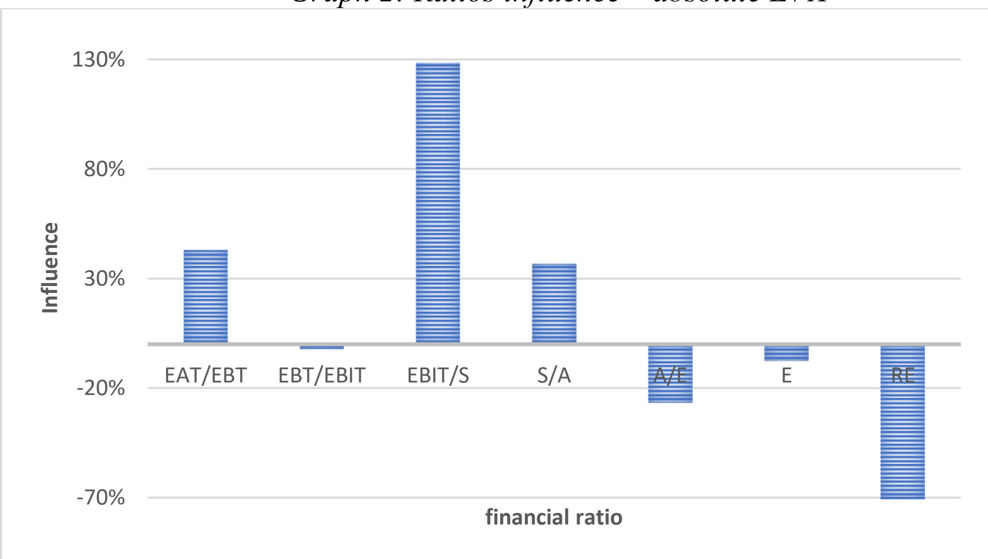
4. Results and discussion

Table 4 and Graph 2 show deviation expected values, furthermore particular and total variances, and the most important information concerning particular influence factors of absolute EVA. According to the analysis results, the highest positive impact is 128,32 % of $EBIT / S$ the ratio. Moreover, a positive influence EAT / EBT of 42,89 % and S / A, an influence of 36,59 %. On the other side negatively functioned R_E -71,20 % and A / E with -26,72 %. The weaker lower impact influence is of E and $EBT / EBIT$.

Table 4 : Results of decomposition – absolute EVA

Financial ratio	**expected value**	**variance**	**influence**
Symbol	$E(\vec{z}_i)$	$s(\vec{z}_i)$	$w(\vec{z}_i)$
EAT/EBT	-1260,6	3653438,6	42,89%
EBT/EBIT	53,8	7174,4	-2,16%
EBIT/S	7315,1	27226084,2	128,32%
S/A	-1895,7	2693971,7	36,59%
A/E	42,8	3394686,2	-26,72%
E	-169,9	54741,3	-7,73%
R_E	-2230,7	7379125,6	-71,20%
Suma			100,00%

Graph 2: Ratios influence – absolute EVA

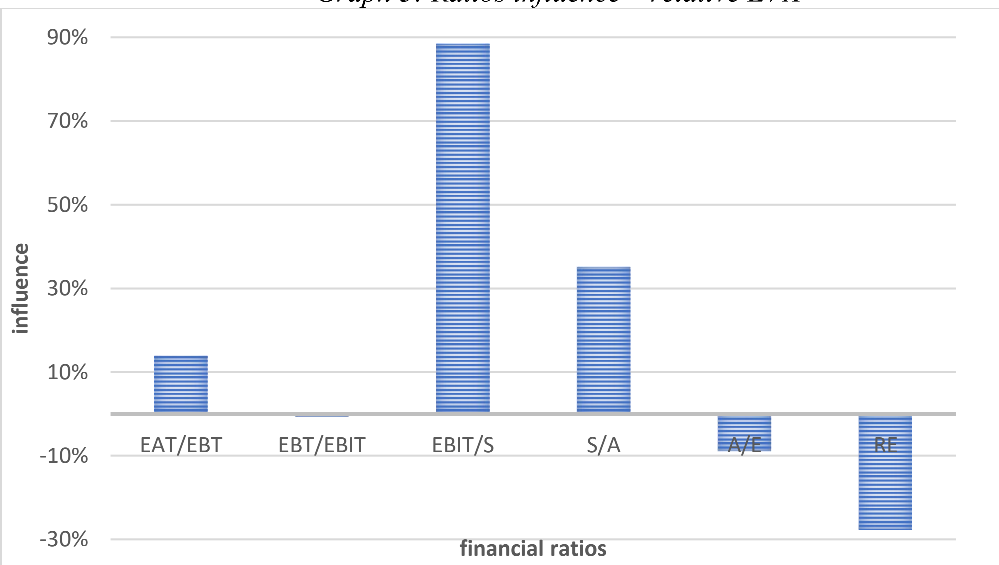


Results of influence analysis for relative EVA are illustrated in Table 5 and Graph 3. Deviation expected values, particular and total variances, and particular influence factors are presented again. It is apparent the highest positive influence is of $EBIT / S$ +88,42 %, moreover S / A +35,11 %, EAT / EBT +13,84 %. Contrary, the highest negative impact is R_E -27,76%, then A / E -8.87 % and $EBT / EBIT$ -0,74 %.

Table 5: Results of decomposition – relative EVA

Financial ratio	expected value	variance	influence
Symbol	$E(\vec{z}_i)$	$s(\vec{z}_i)$	$w(\vec{z}_i)$
EAT/EBT	-0,003397	0,000023	13,84%
EBT/EBIT	0,000149	0,000000	-0,74%
EBIT/S	0,020410	0,000221	88,42%
S/A	-0,005000	0,000015	35,11%
A/E	0,000404	0,000028	-8,87%
R_E	-0,006562	0,000057	-27,76%
Suma			100,00%

Graph 3: Ratios influence – relative EVA



Comparing the absolute and relative EVA influence analysis values, the results are comparable but not the same. The extremely positive and negative influences are the same; the ranking and values of other ratios are different. It implies that absolute equity value changes the influence analysis results because of mutual relation. So the decomposition system is a substantial aspect of dynamic influence analysis.

5. Conclusion

The performance analysis has been under research for a long time, and the results create significant information for the successful management of companies. The static influence is not stable. Therefore, the dynamic analysis can be more fruitful for long-term strategic management. The paper proposed a method of influential dynamic analysis based on the variance analysis methodology. The absolute and relative EVA measure is investigated based on the pyramid decomposition design. It was verified that dynamic analysis could be useful for company analysis. In the example, the extreme influence factors were the same, ranking of the influential factors was different. It is interesting that the most important financial ratios cover the basic characteristics of financial performance, particularly profitability, leverage and liquidity. It was found that the pyramid decomposition system can influence the results. So, the robustness of the influential analysis should be investigated to obtain stable results.

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Telematics in Insurance Industry and Its Perspective at Slovak Insurance Market

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Abstract

In today fast-paced world of technology, each industry is finding ways how to offer the best quality services to its clients in a most effective way. The insurance industry being not an exception, tries to provide with the help of telematics the most suitable insurance services which match driving skills of clients. Successful telematics insurance sold in another countries proves that there is a potential for such an insurance also at the Slovak insurance market where the telematics insurance is currently not present. The paper determines the degree of telematics usage at the present and its possible application in future at the Slovak insurance market.

Key words

telematics, insurance, SOS Partner, eCall

JEL Classification: G14, G22, M15, O14, O31, O32

1. Introduction

In today fast-paced world of technology each industry is finding ways how to offer to its clients the best quality services in a most effective way. The insurance industry being not an exception, tries to provide with the help of telematics the most suitable insurance services which match driving skills of clients. Because of that the telematics processes are becoming increasingly important for owners, operators, and users of motor vehicles in the field of insurance. For insurance companies, it has long been a matter of interest to have credible data on how often, where, when, and how insured vehicles are used. However, without this data, insurance companies must rely only on average estimates based on the driver's age and history in terms of claims.

Telematics technology is an Intelligent Transportation Systems (ITS). It is the outcome of convergence and subsequent progressive unification of telecommunications technologies and informatics, together with the management economy and mathematical methods of creation and management of omnibus systems (Křivda, 2009). The vehicle's telematics is based on M2M[2] communications and represents the exchange of data between remote devices by means of cable and/or wireless communication network for telemetry and remote control (Husnjak, et al. 2014). Currently there are 4 types of telematics devices on the market: dongles, black boxes, built-in telematics devices and smartphones.

From the successful application of telematics at the insurance services could be mentioned for example the telematics insurance launched in 2014 by the company Aioi Nissay Dowa Insurance in Japan. The telematics insurance aimed for teenage drivers in Japan was using the G-book telematics Toyota GPS system. It was launch in response to the fact that most young

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[2] **M2M -** Machine to Machine is a communication between two or more units that do not need any human intervention. M2M services are designed for automatic decision-making and communication processing.

people were losing interest in owning a motor vehicle due to high insurance premiums assessed on their young age and zero previous experience. (Yoon, 2008) The American Transit Insurance being a leader in providing insurance for taxis in New York in 2003 introduced a program that offered a premium discount for taxis using IBM e-Drive. (Vartanian, 2003) The Axa Insurance also used telematics in motor vehicle insurance. This service was aimed at young people aged 18-24 years in Ireland, comparing speed limits with GPS-tracked driving. If the driver exceeded the permitted speed, the alarm alerted him to this fact, and in the case of a later analysis by the insurance company, the price of the insurance premium could increase (Yoon, 2008). In Czech Republic the insurance company UNIQA currently sells the telematics insurance called SafeLine (UNIQA, 2022).

Beside the many positive examples of using telematics at the insurance services, the implementation of telematics services in the insurance industry may be threatened by the intelligent eCall traffic safety system[3]. The importance of eCall is to automatically call the operations center of the integrated rescue system in the event of a serious accident even in situations where neither the driver nor the vehicle crew can call the help. The emergency line 112 could be called manually by pressing a button, where the eCall system works similarly to an emergency call from a telephone but is enriched with the exact location of the call point and all available characteristics of the vehicle from which the emergency call is made (Matoušková, et al, 2015). For motor vehicles manufactured after 31st of March 2018, the installed eCall system using line 112 is mandatory for the EU countries. This standard applies to light commercial vehicles up to 3.5 tons and vehicles with less than 8 seats. eCall works in all EU countries, regardless of where the vehicle was purchased or registered. Activation of the eCall system only takes place when the button is pressed manually or automatically in the event of a serious accident, so that during normal use of the motor vehicle there is no transmission of vehicle position data or monitoring of driving. When eCall is connected to line 112 by telephone, personal data are processed in accordance with the EU's data protection rules. The emergency service is thus provided with only a limited amount of data that is needed to resolve the situation (Regulation (EU) 2015/758). The eCall must be designed to withstand the impact of a vehicle during an accident. The essential of eCall is resistance of at least 10 G and independence from the vehicle's power supply, as the unit may be detached from other vehicle electronic systems in the event of an accident (Matoušková, et al, 2015).

Successful telematics insurance, which is actively sold for example in the Japan, USA, or in the Czech Republic proves that there is a potential for such an insurance also at the Slovak insurance market. Although the telematics insurance at the Slovak insurance market is not reality yet, there have been a one insurance company which did offer such an insurance. The Generali Group (Generali) offered in 2015 – 2021 the telematics insurance in the form of the SOS Partner product (SOS Partner). Therefore, SOS Partner will be for the research purposes used as an example. The pros and cons for the product will be analysed. Based on the paper research the recommendations for successful telematics insurance for the Slovak insurance market will be proposed.

2. Data and Methodology

The main goal of the paper is to is to determine the degree of telematics usage at the present and its possible application in future at the Slovak insurance market where telematics insurance is currently not present.

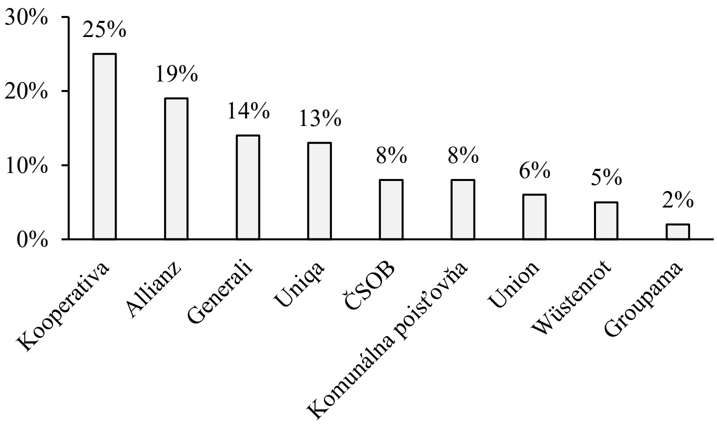
For the research purposes the telematics insurance from Generali - SOS Partner which was offered at the Slovak insurance market in 2015 – 2021 will be used as an example. On basis of SOS Partner, the comparison of the telematics insurance with the other vehicle insurances

[3] **eCall -** the abbreviation of emergency call.

offered at the Slovak insurance market was done. In the model examples, the individual offers of Compulsory Motor Third-Party Liability Insurance (CMLI)4 and Accident Insurance (AI) were compared with and without the use of telematics device from Generali and other chosen insurance companies operating at the Slovak market. Based on the research the recommendations for the degree of telematics usage at the present and its possible application in future at the Slovak insurance market will be proposed.

The calculations were based on parameters of the SOS Partner which are listed in the section 3. In the model examples, the present insurance offers from top five insurance companies operating at the Slovak market are presented. The top five companies were chosen according to the highest number of closed CMLI in 2021: Kooperativa Insurance Company (Kooperativa), Allianz – Slovak Insurance Company (Allianz), UNIQA Insurance Company (UNIQA), ČSOB Insurance Company (ČSOB) and Generali (Slovak Insurance Bureau, 2022).

Figure 1: Share of insurance companies of CMLI in 2021 according to the number of insured vehicles



The model examples were compiled for the ŠKODA Fabia passenger car, which was the best-selling car model in Slovakia in 2021 of 3662 sold units of it (Duľa, 2022). The average age of passenger cars in Slovakia is 14 years (European Automobile Manufacturers' Association, 2020). Because the SOS Partner could be purchased only for a vehicle up to 12 years old, the first model example was worked out with CMLI and AI premiums rates calculated for ŠKODA Fabia with the year of manufacture 2010 (12 years old)5.

Since the eCall system could be a perceived as a threat for the telematics insurance the next calculation did compare the classic motor vehicle insurance with telematics insurance based on model examples for an older motor vehicle and subsequently for a motor vehicle that has the eCall system.

The research of the paper was based on the research of Yoon (2008), Vartanian (2003), Matoušková, et al (2015). The information about the SOS Partner were gained from the website of Generali and from the director of the Motor Vehicle Insurance Section of the Generali, Mr. Ing. Marek Havriľák. The premium rates offered by top five insurance companies were taken from the Slovak insurance portal superpoistenie.sk. The portal considers and compares offers

[4] According to the Act on Compulsory Motor Third-Party Liability Insurance no. 381/2001, the owner of the motor vehicle has the right to choose any insurance company whose offer is most advantageous for him. The obligation to conclude a Compulsory Motor Third-Party Liability Insurance arises for every owner, operator, or lessee of a domestic motor vehicle. It serves to cover the risk of damage that the driver may cause to the health and life of other persons, property, but also to cover the purposefully incurred costs associated with legal representation and lost profits.

[5] ŠKODA Fabia (5J) (2007-2014) Petrol 5-door, 5-m., hatchback, passenger car 1.2 (1197 ccm, 77 kW, turbo).

of chosen insurance product from all insurance companies operating at the Slovak insurance market.

For the research purposes the descriptive statistics were used. To find out most about the telematics insurance the observation and abstraction together with analysis and synthesis were used. The comparison method was used to compare currently offered insurance by six chosen insurance companies operating at the Slovak insurance market. With the help of analysis, a conclusion about the perspective and the use of telematics at the Slovak insurance market was done.

3. Use of telematics at the Slovak insurance market

Use of telematics at the Slovak insurance market is not reality yet. At present, there is no insurance company that offers telematics insurance for vehicles. In the past, telematics insurance was offered only by Generali within a SOS Partner. SOS Partner from Generali thus became a pioneer in telematics insurance at the Slovak insurance market. The SOS Partner from Generali was provided at the Slovak insurance market from 2015 to 2021. As mentioned earlier the insurance could be purchased for AI or for a combination of CMLI and AI for vehicles weighing up to 3.5 tons. The vehicle had to be used only for private purposes and could not be older than 12 years. With this insurance service, a telematics device was installed free of charge in the cab on the windscreen of vehicle in the authorized service. The telematics device was then on rented by the client from the Generali during the insurance period. After the end of the insurance contract, the client had to return the device to the Generali. This device had the built-in SIM card, speaker, and microphone. In case of an accident and a collision with an overload of more than 2.5 G, the telematics device automatically brought this to the attention of the assistance service, which by using a telematics device, tried to connect with the vehicle crew. According to the detected information, the assistance service sent the necessary assistance to the place of the accident. The assistance services were valid only if the accident occurred on the territory of the Slovakia or Czech Republic. The telematics device could also be used by the driver in the event of a failure of the vehicle, when he could contact the assistance service using the button on the device, which provided him with necessary service assistance, such as towing a non-mobile car or refuelling. The territorial validity of this assistance service was in the countries of negotiated insurance and in countries such as Albania, Serbia, and Romania.

Table 2: Basic information about SOS Partner from Generali

Period of sale	7 years
Fee for telematics device in the 1st year	€ 35
Fee for telematics device in the 2nd year	€ 70
Discount on the premium rate of AI in the 1st year	5 %
Possible discount on the premium rate of AI in the 2nd year	10%
Discount on the premium rate of CMLI in the 1st year	10%
Possible discount on the premium rate of CMLI in the 2nd year	20%

By purchasing the SOS Partner, the client automatically received a discount of 5% from the premium rate and a discount of 10% from the premium rate of CMLI. He also gained access to the so called "Quality Driver" portal, where the data obtained from the telematic equipment were evaluated – mileage, type of roads, average time spent on the roads and using complex algorithms, the client's level of prudence, level of risk and level of attention were also determined. If the driver fulfilled the required parameters, for the next insurance period he received a discount of 10% from the premium rate of AI and a discount of 20% from the premium rate of CMLI.

4.1.1 Model Example A, ŠKODA Fabia, year of manufacture 2010

In the Model Example A, we will consider offers of chosen insurance companies for the passenger car ŠKODA Fabia, year of manufacture 2010 for CMLI and AI[6]. According to the price of the CMLI out of five chosen insurance companies, the Kooperativa offers the lowest annual premium rate € 103.75. Only three of chosen insurance companies also offer AI - Kooperativa, UNIQA and Generali. The lowest annual price of AI is from the Generali € 240. The AI is mostly recommended for new vehicles. In the case of older vehicles, AI pays off for vehicles with a higher market value, which is usually in the case of more luxurious brands. We can therefore assume that in the case of a 12 years old ŠKODA Fabia the financial value of vehicle accident and repairs would exceed its market value, which is quite low after 12 years of use. Therefore, this type of insurance for the ŠKODA Fabia vehicle will not be cost-effective.

As could be seen from the Table 3, the advantageous package of combination of CMLI and AI for 12-year-old ŠKODA Fabia is from Kooperativa and UNIQA. These two insurance companies offer a premium discount if both CMLI and AI are bought together, for price of € 383 and € 727.

Table 3: Offers of insurance products from top five insurance companies for the ŠKODA Fabia motor vehicle, year of manufacture 2010

Insurance company / Insurance product	Kooperativa	Allianz	UNIQA	ČSOB	Generali
CMLI	€ 103.75	€ 207.38	€ 180.36	€ 177	€ 231
AI	€ 294	×	€ 549	×	€ 240
CMLI + AI	€ 383	×	€ 727	×	€ 471

In the next model example, we will compare the insurance offers from Generali of CMLI and AI for the 1st year of insurance contract with and without the telematics device, which fixed fee for 1st year of usage is € 35. We will set aside two possible calculations offered by Generali in SOS Partner – having a separate AI or including CMLI together with AI. When the SOS Partner is included in AI, the client would pay € 23 more than for AI without telematics device. If client purchase CMLI together with AI within SOS Partner, he would save only 10 cents compared to the same insurance, which, however, does not use telematics device.

[6] We have chosen CMLI and AI at lowest prices. The cover limit for CMLI was the same € 5.24 MM/ € 1.05 MM. Except ČSOB where the cover limit was € 6,07MM/€ 2 MM. The conditions for AI was the same at UNIQA and Generali with 10% co-participation min. € 330. The conditions for AI at Kooperativa where with 5% co-participation min. € 150.

Table 4: Change in premium rate Generali insurance products for the ŠKODA Fabia motor vehicle, year of manufacture 2010 in the 1st year of SOS Partner

Generali		Premium rate without telematics device	Entry discount CMLI 10% AI 5%	Fee for telematics device in 1st year	Price of SOS Partner
1.calculation	AI	€ 240	€ 12	€ 35	€ 263
2. calculation	CMLI	€ 231	€ 23.1	€ 35	
	AI	€ 240	€ 12		
	Sum	**€ 471**	**€ 35.1**		**€ 470.9**

Similarly, to the Table 4, we will calculate the premiums for possible ways of purchasing SOS Partner, but this time for the 2nd year, where the fee of telematics device increases to € 70. After considering the entry discount of AI, the premium rate is € 286.6. If the conditions for obtaining a discount for the following insurance period were met, the premium rate of AI will be € 275.2.

For the combination of CMLI and AI of SOS Partner insurance, the premium rate after considering the entry price was € 495.4. With a satisfactory driving style, this price could be reduced to € 460.8 for the next insurance period. The premium rate for a product without a telematics device is in both calculations a cheapest option.

Table 5: Change in premium rates on Generali insurance products for the ŠKODA Fabia motor vehicle, year of manufacture 2010 in the 2nd year of SOS Partner

Generali		Premium rate without telematics device	Entry discount CMLI 10% AI 5%	Price of telematics device	Premium rate for the service of SOS Partner	Discount for satisfactory driving style	Premium rate for the SOS Partner for the next period
1. calculation	**AI**	€ 228	€ 11.4	€ 70	€ 286.6	€ 22.8	€ 275.2
2. calculation	**CMLI**	€ 232	€ 23.2	€ 70		€ 46.4	
	AI	€ 228	€ 11.4			€ 22.8	
	Sum	**€ 460**	**€ 34.6**		**€ 495.4**	**€ 69.2**	**€ 460.8**

From the **model example A**, we can conclude that there is only one option where the client could save thanks to the SOS Partner, namely when purchasing CMLI together with AI in the 1st year of SOS Partner, where the price of telematics device is lower as in the 2nd year of its usage. From the model example A, we can say that such a product is not primarily intended to provide more cost-effective insurance, but the client will purchase it due to the benefits of assistance and rescue services in the event of an accident.

4.1.2 Model example B, ŠKODA Fabia, year of manufacture 2021

In the model example B, we will analyse the relevance of the SOS Partner for a passenger car with built-in intelligent transport system eCall. For the ŠKODA Fabia, year of manufacture 2021. In all 3 insurance product options – CMLI, AI and conclusion of CMLI and AI, the lowest price of CMLI € 103.75 and AI € 259 is from Kooperativa. In the case of concluding CMLI and AI, the client receives a discount of € 12.75 and pays annual premium of € 350.

Allianz and UNIQA also offer a discounted package of CMLI and AI. In the case of purchase of CMLI and AI from ČSOB and Generali, the offers of these separate products are simply added up.

Table 6: Offers of insurance products from top five insurance companies for the ŠKODA Fabia vehicle, manufacture year 2021

Insurance company / Insurance product	Kooperativa	Allianz	UNIQA	ČSOB	Generali
CMLI	€ 103.75	€ 228.48	€ 192	€ 160	€ 210
AI	€ 259	€ 498	€ 335	€ 304	€ 410
CMLI + AI	€ 350	€ 498	€ 501	€ 464	€ 620

Subsequently we will take SOS Partner which is offered by Generali in two ways:

1) AI,
2) CMLI and AI.

We will apply the entry discount 5% for AI and 10% for CMLI. To the premium rate we will add the fee for telematics device which is in the 1st year € 35. In the case of AI the premium rate is € 424.4, which is € 14.5 more than the price of AI without the telematics device from Generali. In the 2nd case the price for CMLI and AI will be cheaper by € 6.58 in compare with premium rate for the same insurance combination without the telematics device.

Table 7: The change of premium rate from Generali for the ŠKODA Fabia vehicle, manufacture year 2021 in the 1st year of SOS Partner

Generali		Premium rate without telematics device	Entry discount CMLI 10% AI 5%	Price of telematics device	Premium rate for the SOS Partner
1. calculation	**AI**	410 €	20.5 €	35 €	424.5 €
2. calculation	**CMLI**	210.82 €	21.08 €	35 €	
	AI	410 €	20.5 €		
	Sum	**620.82 €**	**41.58 €**		**614.24 €**

Because the fee for the telematics device doubles after 1st year of the insurance contract, next calculation will take to the consideration the premium rate in the 2nd year of the insurance contract. In the 1st year of AI when entry discount of 5% and fee for telematics device is included in the annual premium rate of € 459.5. In the case of client´s satisfactory driving, the granted discount in the 2nd year would be 10%, so the premium rate will lower to € 439.

In the case of CMLI and AI package the annual premium rate is € 649.24. In the case of client´s satisfactory driving style, the client can get a discount of € 83.16, where the annual premium rate would be € 607.66.

Table 8: 10: Change of the annual premium rate for the ŠKODA Fabia, year of manufacture 2021 in the 2nd year of SOS Partner

Generali		Premium rate without telematics device	Entry discount CMLI 10% AI 5%	Price of telematics device	Premium rate for the SOS Partner	Discount for satisfactory driving style CMLI 20% AI 10%	Premium rate for the next year of SOS Partner
1. calculation	**AI**	€ 410	€ 20.5	€ 70	€ 459.5	€ 41	€ 439
2. calculation	**CMLI**	€ 210.82	€ 21.08	€ 70		€ 42.16	
	AI	€ 410	€ 20.5			€ 41	
	Sum	**€ 620.82**	**€ 41.58**		**€ 649.24**	**€ 83.16**	**€ 607.66**

The model example B was calculated for the passenger car ŠKODA Fabia manufactured in 2021 which thanks to the built-in eCall system, no longer needs one of the most important telematics capabilities of the SOS Partner, the ability to call the rescue services in the event of an accident. The SOS Partner is therefore attractive for potential clients, especially in terms of a possible lower premium rate. In our model example, however, the premium rate of separately purchased AI with SOS Partner in the 1st year of insurance contract exceeded the premium rate of AI without telematics device. The same case is in the 2nd year of the insurance contract where the fixed fee for telematics device is increased from € 35 (1st year) to € 70. Therefore, the AI of SOS Partner is for the owner of vehicle with built-in eCall system not beneficiary.

If the CMLI and AI package is bought in the 1st year when the fee for telematics device is € 35, the client could save € 6.58. In the 2nd year when the fee for telematics device is increased to € 70, the client could save € 13.16. But that is only in the case of satisfactory driving style of the client.

For the owner of the passenger car ŠKODA Fabia with built-in eCall, in the case of purchasing AI of the SOS Partner, the premium rate will not pay off, as it is in all possibilities higher than the premium rate for AI without telematics device. In the case of purchasing CMLI and AI package of the SOS Partner, the premium rate may be reduced, but the amount of the discount is not high enough to motivate clients to purchase the SOS Partner.

4. Conclusions and recommendation for application of telematics at Slovak insurance market

High homogeneity of insurance services prevails among the insurance products of various insurers operating at the Slovak insurance market. In the last six years of selling of telematics insurance SOS Partner from Generali, no other Slovak insurance company has decided to provide telematics insurance. On basis of done research, we can conclude that this fact is due to several factors, such as the high cost of telematics, insufficient demand from clients or fear of reputational risk for the insurance company.

For decreasing the high costs of telematics, we would suggest the use of smartphones instead of costly telematics device. Smartphones contain sensors such as accelerometers and gyroscopes that can be used to collect data. They also have large storage space and access to high-speed internet, allowing immediate data transfer to the insurance company (Yao, 2018). Another possibility for lowering the cost could be a cooperation with other insurance company operating at the EU market on its development and in this way to share the costs.

On basis of research, we can conclude that there are three main reasons for the insufficient demand from the side of clients. The first reason is the uncertainty of obtaining a discount, which depends on meeting the driving requirements. The second reason is very low, directly negligible difference between premiums rate in telematics insurance and the premiums rate in conventional insurance. The third reason might be that the SOS Partner was primary sold for accident insurance, which is important especially for new motor vehicles with a high market value. But such vehicles already have a mandatory eCall system, so the main function of the SOS Partner product - to automatically call rescue services in the event of an accident, does not represent any advantage for their owners. The advantage from the telematics insurance is the fact, that motor vehicles manufactured before 2018 predominates in Slovakia, and the telematics insurance, in addition to the insurance itself and summoning of rescue services, also provides of assistance services.

Since the SOS Partner is no longer provided due to low interest from the clients' side, we can assume that clients did not perceive the benefits of this product but considered the SOS Partner exclusively as ordinary insurance which was more expensive than the other offered at the Slovak insurance market. Therefore, we would suggest raising awareness of telematics among potential clients, especially among young people. Young people have higher premium rates due to their young age. The premium rate could be in this case lowered based on their satisfactory driving style. The clients should be also ensured that the collected data will not be misused. Positive example could be the SOS Partner, where the collected data were sent to the server of the Generali in Italy and the collected data were used in the case of collision and for the premium rate calculation only.

Another important fact which came out the research it the fact that the premium rates for the Compulsory Motor Third-Party Liability Insurance and Accident Insurance are very low at Slovak insurance market in comparison with the countries where the telematics insurance is successful7. Because of that we can conclude that for the successful implementation of telematics at the Slovak insurance market, also the increase of the premium rates is needed. Otherwise, a low discount of telematics insurance does not motivate for buying as well as providing the telematics insurance. Slovak insurance companies could also get more information about implementation and successful selling of telematics insurance from other EU countries. For example, from the Czech insurance company UNIQA which actively sells the telematics insurance SafeLine nowadays (UNIQA, 2022). Alto there are still several challenges to be solved before the telematics will be used again for the insurance services offered at the Slovak insurance market, we do see the future perspective of the telematics insurance in Slovakia. The positive examples from the other countries where telematics insurance is not new anymore proves that telematics insurance could be attractive also for the Slovak vehicle insurance consumers.

[7] For example, the average cost of car insurance in August 2022 at the US insurance market was $ 1.771 per year for full coverage, while minimum coverage is $545 per year. (Bankrate, 2022)

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COVID-19 pandemic and its effect on Slovak economy

Zuzana Gajdošová, Andrea Snopková[1]

Abstract

Slovakia was hit by COVID-19 pandemic in March 2020. From then on is the infection by COVID-19 virus a daily reality of Slovak citizens. The side effect of the anti-pandemic shut down measures of Slovak government have had a significant negative effect on development of Slovak economy. The aim of the paper is to analyse the impact of the COVID-19 pandemic on the performance of the Slovak economy. Four economic indicators were chosen: Total Sales, Unemployment Rate, New Consumer Credits and Public Debt on GDP. For the research purposes comparison and descriptive statistics were used. Based on the analyses Slovak economy was impacted by COVID-19 mainly in the year 2020.

Key words

COVID-19 pandemic, Slovak economy, Total Sales, Unemployment Rate, Consumer Credit, Public Debt on GDP

JEL Classification: E21, E23, E24, H63, J64

1. Introduction

The COVID-19 pandemic, also known as the coronavirus pandemic, is an ongoing global pandemic of coronavirus disease which was first identified in the Chinese city of Wuhan in 17th November 2019 (The Guardian, 2020). The World Health Organization (WHO) declared a Public Health Emergency of International Concern on 30 January 2020 and a pandemic on 11 March 2020 (WHO, 2020). By the end of March 2022, the pandemic had caused more than 479 million cases and over 6 million deaths (WHO, 2022), making it one of the deadliest in the world history. It has affected the health of the public and economies (American University of the Middle East, 2020). Some sectors have been hit harder than others, and there have been different impacts on the labour market depending on age, gender, and level of education (Claéys, et al., 2021).

It has had a substantial impact on the EU27 economy and triggered unprecedented policy responses across Europe and the globe (European Parliament, 2021). Various measures have been taken to prevent proliferation, but these have an impact on a wide range of economic activities around the world (Staboulis, Lazaridou, 2020). The restrictive shut down measures adopted for controlling the spread of COVID-19 pandemic have had a negative impact on economic activities and created a new crisis that is assumed to be more devastating compared to crises which we have faced before (Jebran, Chen, 2020). The strictness of lockdown measures, the share of tourism in the economy, and the quality of governance play a significant role in explaining differences in economic losses in different EU countries (Sapir, 2022). Southern European countries have been particularly strongly affected (Claéys, et al.,

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2021). There have been also remarkable differences in performance across the industries and within sectors (European Parliament, 2021).

From the perspective of local public entities responsible for service provision, the COVID-19 pandemic is unprecedented. They offer a framework for navigating the fiscal effects of COVID-19 and rely on recent surveys to assess the response strategies of local governments that are now trying to figure out their financial condition moving into the next budget cycle. (Maher, Hoang, Hindery, A. 2020)

The aim of the paper is to analyse the impact of the COVID-19 pandemic on the performance of the Slovak economy in connection to COVID-19 virus infection and successful or non-successful vaccination strategy applied by Slovak government. So far there have not been a research which would connect virus infection, vaccination of citizens with local economy performance. Therefor the article will provide another point of view on COVID-19 pandemic and its effect on chosen EU country´s economy.

Besides the data of COVID-19 vaccination of Slovak citizens and daily COVID-19 cases in Slovakia, the four economic indicators were chosen: Total Sales, Unemployment Rate, New Consumer Credits and Public Debt on GDP. The gained results from the research are expected to contribute to the increasing debate about the current pandemic crisis and its consequences for the local economies.

2. Data and Methodology

The aim of the paper is to analyse the impact of the COVID-19 pandemic on the performance of the Slovak economy in connection to COVID-19 virus infection and successful or non-successful vaccination strategy applied by Slovak government. Beside the data of COVID-19 vaccination of Slovak citizens and daily COVID-19 cases in Slovakia, we have chosen the four economic indicators: Total Sales, Unemployment Rate, New Consumer Credits and Public Debt on Gross Domestic Product (GDP). The reason for choosing stated indicators was to analyse the impact of COVID-19 on main representatives of Slovak economy: businesses operating at the Slovak market (Total Sales, Unemployment Rate and Consumer Credits), households (Unemployment Rate & Consumer Credits) and on state (Public Debt on GDP). The start of analysed period differs per indicator according to its relevance. The end of analysed period of chosen indicators is the end of 2021 (Public Debt on GDP), January 2022 (Total Sales) and end of March 2022, when the significant decline of COVID-19 cases was received, and Slovak economy started to be negatively affected by Russian and Ukrainian conflict2.

This paper uses qualitative research and secondary research. For the research purposes comparison and descriptive statistics were used. The information available in the resolutions and restrictive regulations of national governments, data published by Slovak governmental institution such as korona.gov.sk, National Bank of Slovakia, Institute of Health Analysis of the Ministry of Health of the Slovak Republic, Central Office of Labour, Social Affair and Family and Slovak Debt and Liquidity Management Agency and media articles published before 22nd August 2022.

3. Impact of COVID-19 pandemic in Slovakia

The first risk management decision of Slovak government was addressed by strong anti-pandemic shutdown measures in March 2020 (Public Health Authority of the Slovak Republic, 2020). It was almost immediately following the identification of the first COVID-

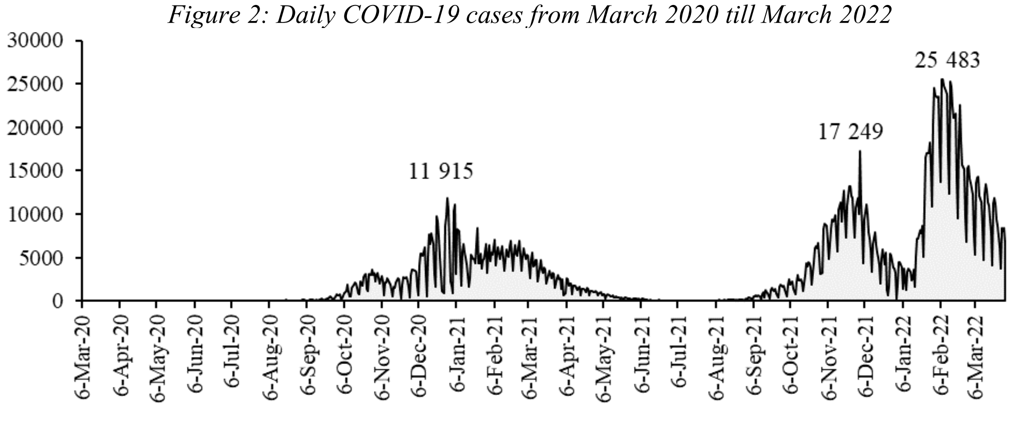
[2] On 24 February 2022, Russia invaded Ukraine, in a major escalation of the Russo-Ukrainian War that began in 2014.

19 positive citizens in the country (6 March 2020). During the first wave of the pandemic was the main goal of Slovak government mitigate the threat of high number of infected citizens. The first anti-pandemic shutdown measures from 8th – 16th March 2020 included, for example, closing of all schools and shops except grocery stores, drugstores, and pharmacies, but also the operation of bars, hotels, fitness centres, sports clubs, services, etc. All mass events have been cancelled and banned (Public Health Authority of the Slovak Republic, 2020).

The measures had a significant impact on the owners of the businesses operating at the Slovak market and their employees (Svabova, Metzker and Tomasz, 2020). During the summer of 2020, the measures were eliminated (Koronavírus a Slovensko, 2020). From September 2020 onwards, the number of diagnosed COVID-19 infections gradually began to increase and the government reintroduced anti-pandemic measures to reverse the undesirable development (Slovak Government Office, 2020a).

In December 2020 another anti-pandemic measures were introduced including lockdown from 19th December (Slovak Government Office, 2020b). On 1st January 2021 the anti-pandemic shutdown measures were toughened again (Osvaldová, Gehrerová, Mikušovič, 2021), and it continued till late spring 2021 (Ministry of Health of the Slovak Republic, 2021a). Similarly, to 2020, in the summer 2021 the measures were eliminated (Ministry of Health of the Slovak Republic, 2021b). And with coming of autumn the restrictive measures were introduced again (Ministry of Health of the Slovak Republic, 2021c). On December 8th, 2021, Slovak prime minister had announced another lockdown. Crowded hospitals with mostly unvaccinated people were the most important reason for that. "However, the restrictions are causing huge damage to the economy - in terms of lost profits, sales and wages", stated Slovak prime minister Mr. Eduard Heger (Slovak Government Office, 2022). The anti-pandemic shutdown measures slowing down Slovak economy continued with some variations till the end of spring 2022. Development of COVID-19 positivity in Slovakia is shown in Figure 2 (Institute of Health Analysis of the Ministry of Health of the SR, 2022).

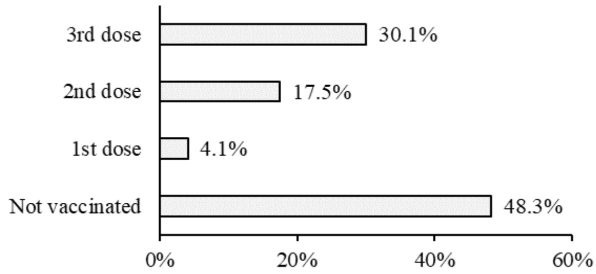
Figure 2: Daily COVID-19 cases from March 2020 till March 2022



3.1 Vaccination, hope for better tomorrow

On 17th June 2020, in order to fight the COVID-19 pandemic which was spreading thru all EU countries, the European Commission (EC) presented the EU Vaccines Strategy against COVID-19 with believe that EU economy will bounce back more quickly than expected, owing in part to the quickening pace of its vaccination programme ((European Commission, 2021). Slovak government has put quite an effort to stimulate the National Vaccination Strategy Against COVID-19. The expectancy of the National Strategy was a collective protection of the society (collective protection). To gain the collective protection, the revaccination of more than 60-70% of the Slovak citizens was needed (Ministry of Health of the SR, 2020). The most of Slovak citizen have soon shown a low trust toward the efficiency of the vaccination (Statista, 2022). The adequate information about the vaccination were missing (European Commission, 2022). Five top reasons for resistance of Slovak citizens against vaccination were a believed that: 1. vaccines were developed too fast, 2. fear of side effects, 3. concern I cannot receive the vaccine for health reasons, 4. fear of unknown long-term effects, 5. young people do not need the vaccine (Ministry of Health of the SR, 2021). The vaccination of Slovak citizens is shown in Figure 2 (Koronavírus a Slovensko. 2022).

Figure 2: COVID-19 vaccination of Slovak citizens from December 2020 till March 2022

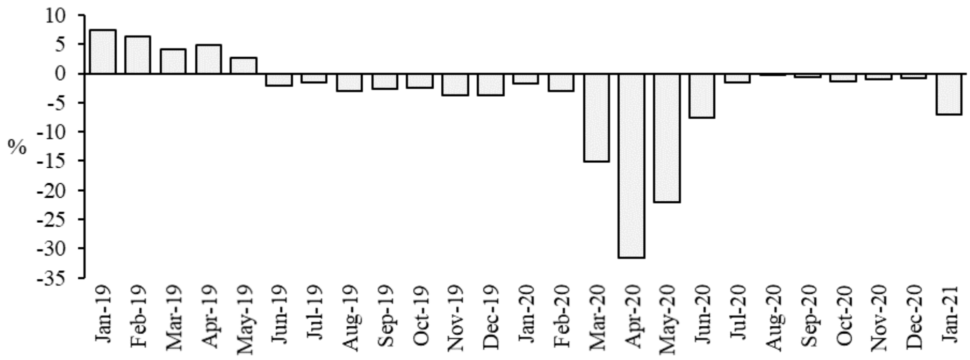


According to number of vaccinated citizens was Slovakia in the March 2022 the 6th worst out of all 27 EU members (Statista, 2022).

3.2 Economic indicators of Slovak economy in COVID-19 pandemic

The impact of COVID-19 pandemic on Slovak economy could be seen from development of chosen economic indicators. Development of private sector - enterprises could be identified from the development of Total Sales and Unemployment Rate. The *Total Sales*[3] of Slovak private sector in the period of January 2019 till January 2022 could be seen in the Figure 3 (National Bank of Slovakia, 2022). The significant drop of Total Sales followed the identification of the first COVID-19 positive citizens and the anti-pandemic shutdown measures in Slovakia. In April 2020 the Total Sales were -31,5% in comparison with Total Sales in April 2019. The Total Sales were stabilized in the July 2019, where the Total Sales were in comparison with the July 2019 lower only by 1,5%. It was undoubtedly thanks to elimination of the measures, which had been slowing down the Slovak economy in the previous months. The Total Sales have continued with positive development till the January 2022[4].

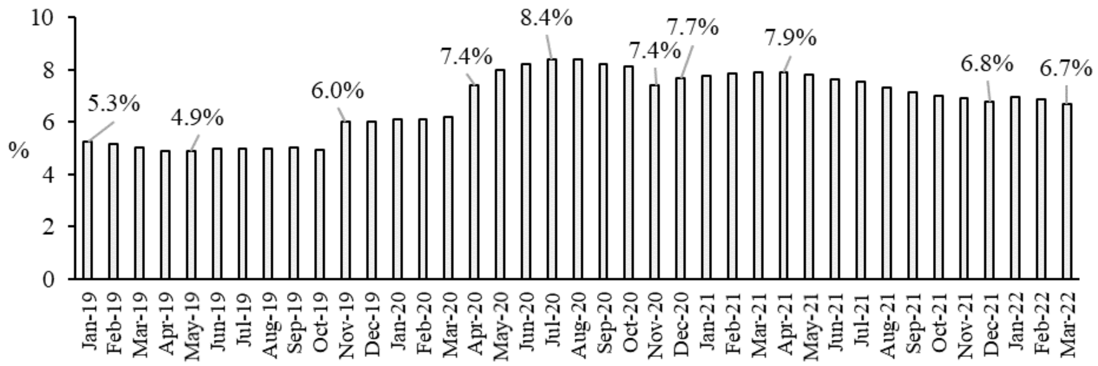
Figure 3: Total Sales from January 2019 till January 2022



[3] The indicator of Total Sales represents the sum of total sales of Slovak private sector year-on-year changes, at constant prices, seasonally adjusted
[4] The data provided by National Bank of Slovakia of Total Sales are only till January 2022.

Another important economic indicator is the *Unemployment Rate* which reflects the inability of an economy to generate employment for those persons who want to work but are not doing so, even though they are available for employment and actively seeking work (International Labour Organization, 2022). Therefore, is the indicator seen as the efficiency and effectiveness of an economy to absorb its labour force and of the performance of the labour market. The low unemployment is therefore perceived as a positive sign for the economy – of the businesses. From social point of view, the unemployment rate negatively affects the disposable income of families, erodes purchasing power of the citizens and therefore reduces an economy's output. Therefore, the Unemployment Rate reflects the situation of the households as well as the economy as such. Due COVID-19 pandemic restrictive measures, the unemployment has increased worldwide ((International Labour Organization, 2022). The Unemployment Rate at the Slovak market before COVID-19 pandemic was about 5% to 6%. From April 2020, the first month after the anti-pandemic shutdown measures were applied, has the Unemployment Rate risen to 7,4%. The growth had continued till July 2020, where the unemployment rate has reached its historical maximum 8,4%[5]. In November 2020 has the rate fallen to 7,4% and for the next 10 months has it fluctuated between 7% to 7,9%. In March 2022 has the unemployment rate fallen to 6,7%, which was the lowest in the last 22 months, Figure 4 (Central Office of Labour, Social Affair and Family of the SR, 2022).

Figure 4: Unemployment Rate from January 2019 till March 2022



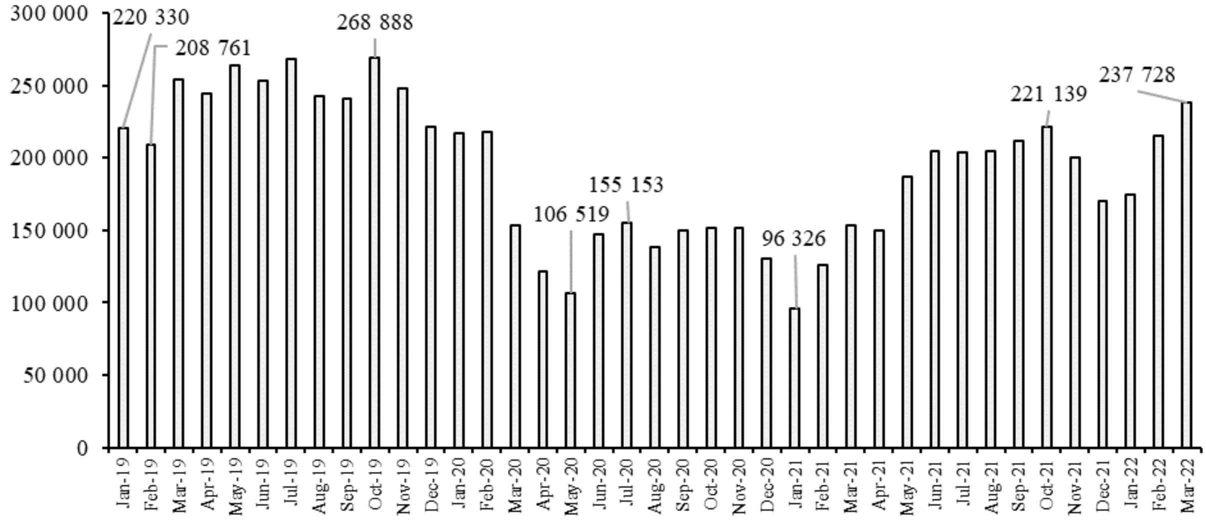
In time of economic recession, the opportunity of credit is often used. According to the World Bank Group research from November 2021, the COVID-19 pandemic and associated global recession in 2020 have caused a surge in global debt levels, both of private debt and government debt (World Bank Group, 2022).

Private debt could be identified by the *Consumer Credit* indicator. According to Slovak Act of 9th March 2010 is the Consumer Credit a temporary provision of funds under a consumer credit agreement in the form of a loan, credit, deferred payment, or similar financial assistance provided by a creditor to a consumer.[6] The Consumer Credit is provided to

[5] The last time when the Unemployment Rate in Slovakia was 8,4% was in February 2017.
[6] Slovak Act of 9 March 2010 on consumer credit and other credit and loans for consumers and on the amendment of certain laws, § 1, (2 - 3). Consumer credits according to Slovak law do not include a mortgage loan and a municipal loan according to a special regulation, a housing loan according to the general regulation on housing loans, a loan secured by a lien on real estate, a loan intended to acquire or retain property rights or construction of real estate, a loan provided to the owners of flats and non-residential premises represented by the administrator or the association of owners for the purposes of a special regulation.

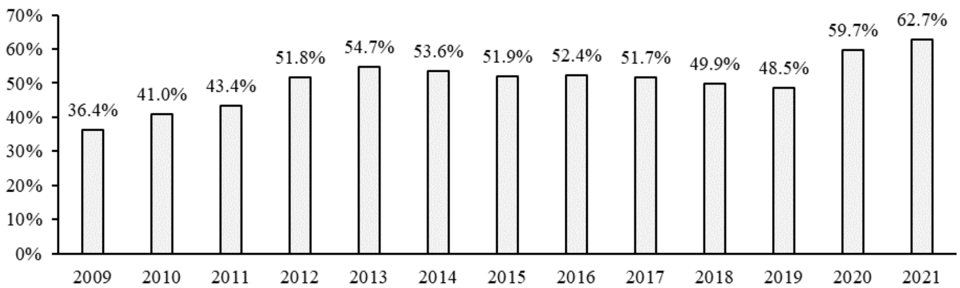
enterprises and households. As could be seen in the Figure 6, Consumer Credits which were already approved by financial institutions had in 2019 positive development. Businesses operating at the Slovak market and households were more likely to take credit in this year. The highest amount of approved Consumer Credits was in October 2019 in the volume of 268 888 thousand euro. From the November 2019 till the May 2020 (106 519 K) had the Consumer Credit negative development. From June 2020 had it a slight increase. And from the December 2020 till the January 2021 has the amount of Consumer Credit decreased again. In January 2021 has the amount of Consumer Credit reached it historical minimum in 24 last months in the amount of 96 326 thousand euro which is almost 54% less than it was in January 2019. From then on has the Consumer Credit positive development till March 2022. Exception are only the months - December 2021 and January 2022. In March 2022 was the amount of Consumer Credit 238 728 thousand euro which is 6,5% less then was in March 2019 (Internal statistic data of National Bank of Slovakia, 2022).

Figure 6: Approved Consumer Credits of Slovak households from January 2019 till March 2022



Government debt is identified by the *Public Debt on GDP* indicator which measures the gross debt of the general government as a percentage of GDP. Public Debt on GDP is a key indicator for the sustainability of government finance (OECD, 2022). According to Maastricht Treaty the Public Debt on GDP of EU countries should not be higher than 60%. The Public Debt on GDP of Slovakia has increased from 2009 to 2013 by 36,4%. In the 2013 has the indicator reached its historical maximum to 54,7% (Figure 7).

Figure 7: Public Debt on GDP from 2009 till 2021 of Slovakia



From then on until 2019 had the Public Debt on GDP negative development. The change came in past two years of COVID-19 pandemic. The Public Debt on GDP increased in 2020 to 59,7% and in 2021 reached its historical maximum 62,7% which is the highest in the history of Slovak Republic[7] (Debt and Liquidity Management Agency, 2022).

4. Results and conclusions

The COVID-19 pandemic as the one of the deadliest pandemic in the world history, has put the humanity in an extremely hard situation. European commission together with leaders of its member states have tried hard to stabilize EU economy. One of the important risk management measures from the European Commission side was the EU Vaccines Strategy. Slovakia was hit by COVID-19 pandemic in March 2020 (Public Health Authority of the Slovak Republic, 2020). From then on is the infection by COVID-19 virus a daily reality of Slovak citizens. Slovak government has tried to stimulate Slovak economy by the National Vaccination Strategy Against COVID-19. But because the Slovak citizens have shown a low trust toward the vaccination this strategy did not work out as hoped. Slovakia remains the 6th worst out of all 27 EU members according to number of vaccinated citizens (Statista, 2022).

Multifarious approaches of risk management explored by Slovak government for combating a pandemic spread with the main goal - to mitigate the threat of a high number of infected citizens. The development of the Slovak economy in the last 2 years went simultaneously with the COVID-19 positivity and anti-pandemic shutdown measures which were applied according to the number of infected citizens. There has been a certain seasonality of COVID-19 infections. The infections have been increasing with the coming of autumn and decreasing with the coming of summer.

The analysis has shown that the Total Sales of the Slovak private sector were the most negatively affected by anti-pandemic measures in March to May 2020. On average were the Total Sales in compared with 2019 in 2020 negative by 7,21 pp and slightly higher in 2021.

Similarly, the Unemployment Rate in compared with 2019 in 2020 went up by 2,34 pp and went down by 0,06 pp in 2021. The positive development – decrease of the Unemployment Rate is continuing till March 2022 (0,74 pp cf. 2021).

The indebtedness of businesses operating at the Slovak market and Slovak households has according to taken Consumer Credits declined by the coming of COVID-19 pandemic. Avg. Consumer Credit from 2019 to 2020 was lower by 37%. In 2021 has the avg. Consumer Credit went up again by 13%. And the same situation is till now - in 2022, where we see the grow of Consumer Credits (15% cf. 2021). Public Debt on GDP did have in 2014 to 2019 negative development. The indebtedness of Slovak state has gone from 2019 to 2021 significantly higher. The Public Dept on GDP went from 2019 to 2020 by 11,2 pp. In 2021 has the increase slow down and the difference between 2020 and 2021 was by 3 pp.

Table 1: Summary of analysed data

	Average of 2019	**Average of 2020**	**Average of 2021**	**Average of 2022**
Total sales	0.5%	-7.2%	8.8%	10.6%
Unemployment Rate	5.18	7.5	7.46	6.72
Consumer Credit	244 539	153 249	177 413	208 972
Public Debt on GDP	48.5%	59.7%	62.7%	-

On basis of analysed data, we can conclude that COVID-19 pandemic and risk management anti-pandemic shut-down measures applied by Slovak government to combat a pandemic spread, have had a significant impact on Slovak economy. The measures have had impact on three main economic subjects - businesses, households, and state. Due to slower

[7] From the day of the Establishment of the Slovak Republic (Slovakia), 1st of January 1993.

economy, businesses operating at the Slovak market have suffered a drop in the Total Sales, especially in 2020. When economy is growing slow, unemployment rises which was also seen in the last two years (Levine, 2013). The Unemployment Rate has risen from avg. 5,18% (2019) to avg. 7,51% in 2020. The increase of Unemployment Rate negatively affects disposable income of households. If the disposable income of households decreases the purchasing power of households decreases too (OECD, 2015) and, in the end, it results in slower economy.

Even thou in past two years the Total Sales of businesses decreased, and the Unemployment Rate increased; demand of businesses operating at the Slovak market and Slovak households for the Customer Credits went down. The COVID-19 pandemic in Slovakia has led to opposite effect as was proposed by World Bank Group (2022), which was that the pandemic has caused a surge debt levels on private debt. The most significant drop in the amount of Customer Credit was from in 2020 by 37%.

In connection with slower economy, Slovak state has similarly to businesses operating at Slovak market and Slovak household suffered from the COVID-19 pandemic. The side effect of risk management COVID-19 pandemic measures from the governmental side was the Public Debt on GDP after six years of positive development – decreasing in its value, increased from 48,5% (2019) to 59,7% in 2020. In this case the expectation of World Bank Group (2022), that the COVID-19 pandemic has caused a surge in government debt was fulfilled.

On basis of analysed data, we can conclude that the side effect of the anti-pandemic shutdown measures applied by Slovak government had a significant negative effect on development of Slovak economy. From the past two COVID-19 pandemic years 2020 and 2021, we came to the end that the Slovak economy was mainly affected in 2020. All four chosen economic indicators have reported the most negative values in this year. In 2021 the reported values are slightly better, and the beginning of 2022 seems even more positive. The question is what the reaction of Slovak economy on Russian and Ukrainian conflict will be since the economical connection between these three countries is not negligible.

Another finding is that the COVID-19 pandemic reminded us that pandemics are even in the 21st century a serious threat for the human civilization and vaccinations are a useful tool in the fight against them. The failure of the Slovak National Vaccination Strategy Against COVID-19 has shown serious gaps in the Slovak education system. Almost 50% of Slovak citizens have not been willing to be vaccinated against COVID-19. Behind the vaccine hesitancy was according to findings of Ministry of Health of the SR (2021) mostly unfounded fear that vaccines were developed in too short time, fear of health harm and believe that young people do not need the vaccination. Slovak government should allocate more financial resources in the national education system so the understanding of importance of vaccination in the context of world history will be increased. Similarly, to financial literacy, the COVID-19 pandemic has proved the impact of individuals knowledge used in their daily decision-making process on the economy.

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Aviation kerosene prices forecast based on the optimized VMD and SVM model[1]

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Abstract

With the development of financial technology and the advancement of the global crude oil market, the complexity of the refined oil market has gradually become prominent. Higher requirements are placed on the accuracy and stability of medium and long-term price forecasting. The objective of the paper is the development and proposal of combined forecasting model based on optimal variational modal decomposition and support vector machine for given commodity price. The paper is structured as follows. First, the aviation kerosene time series with high volatility is decomposed into a set of relatively stable modal components, in which the key parameters of VMD are optimized by the sparrow intelligent algorithm. Secondly, the support vector machine method with different structural parameters is used to predict each component separately, and finally, the prediction results are superimposed to obtain the final predicted value. Taking the actual price data of aviation kerosene as an example to compare with the conventional forecasting method, the effectiveness of the method is verified.

Key words

Price prediction; Variational modal decomposition; Sparrow search algorithm; Support vector machine; Aviation kerosene

JEL Classification: C50, C51, C53

1. Introduction

Aviation kerosene price forecasting is an important part of airline operation scheduling, procurement planning, and production planning of refineries. It can help the refined oil system maintain a balance between supply and demand while reducing resource waste and refining costs. However, with the intensification of nonlinear and unstable characteristics of crude oil price data, it has increased the difficulty of forecasting the price of aviation kerosene. Therefore, it is necessary to use new methods and techniques to improve the accuracy and reliability of price forecasts to meet market requirements.

The current statistical and intelligent forecasting methods are commonly used methods for aviation kerosene prices. Statistical methods mainly include time series analysis, regression models etc. (Hu et al., 2017; Kae, 2003). These kinds of methods have simple models but poor nonlinear fitting ability. The intelligent method is to use historical price data and even various external factors that affect the price as input and make predictions based on various artificial intelligence methods, which are typically represented by BP neural network, Long short-term memory (LSTM), etc. (Andenberger, 1973; Brockwell, et al., 2009). BP neural network has the characteristics of many adjustable parameters and good operability, but its generalization ability is limited, and it is easy to fall into local optimum (Li, 2020). LSTM can better solve problems such as nonlinearity and local minima, but when dealing with large-scale data, the prediction accuracy is low and the computation is time-consuming (Barocio et al., 2015). Deep

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learning algorithms such as SVM are research extensions of traditional artificial intelligence algorithms. Due to the use of multi-layer nonlinear transformations, they can more effectively represent complex relationships in price data. Currently, they have become a research hotspot in financial commodity futures price forecasting (Boyd, et al., 2011).

In order to overcome the limitations of traditional models, this paper will use the OVMD-SVM coincidence prediction model to predict the decomposed signals separately. Experimental results show that the prediction accuracy of these methods is better than that of a single traditional model. The main goal of this paper is to use the OVMD method to decompose the original signal, and then make predictions on the decomposed data, and finally get the prediction value that reduces the accumulated error. Variational modal decomposition with digital signal processing and support vector machine techniques for machine learning. Based on VMD combined with SVM, this paper models and predicts the daily price data series of kerosene and jet fuel from Index Mundi in the US Gulf Coast.

So far, few scholars have used OVMD combined with SVM to predict commodity prices. The jet fuel price data is a non-stationary nonlinear time series because it is trendy and periodic (mean and variance change over time). The article uses VMD to decompose the time series into several IMFs, each of which is a time series signal. These temporal signals have distinct patterns relative to the original signals that can be mined, and SVMs are used to predict these signal sequences separately. The empirical results of the article show that the model works well.

2. The basic principle of forecasting aviation kerosene price based on VMD and SVM optimized by Sparrow Search Algorithm

Following sub-sections provide general description and necessary mathematical background of models employed in the price forecasting.

2.1 Sparrow Search Algorithm (SSA)

Sparrow Search Algorithm (SSA) is a bionic intelligent algorithm proposed by Xue, et al., (2020), which simulates the foraging and anti-predation behaviors of sparrow populations [Seong-Taek, et al., 2001). When foraging, the entire sparrow population is divided into two sub-populations with a fixed proportion of discoverers and joiners. According to the foraging rules, the finder guides the population to search and forage through location updates. Some participants choose to follow the finder to obtain food, and some participants choose to constantly monitor the finder and participate in food competitions in order to increase their predation rate. When the sparrow population is aware of the danger, sparrows in different positions will choose the corresponding escape strategies. The performance of the SSA algorithm is better than the common Grey Wolf Optimization (GWO), Particle Swarm Optimization (PSO), and Moth-flame Optimization (MFO) in terms of accuracy and stability and has a better search capability, so SSA is chosen to optimize VMD.

2.2 Theory of Variational Mode Decomposition (VMD)

Variational mode decomposition VMD is a new non-stationary signal adaptive decomposition estimation method proposed by Dragomiretskiy (2014), which can decompose the original signal into certain K frequency band sub-signals. It abandons the recursive solution mode of EMD, and the decomposition result is less affected by noise (Huang, 1998). The key to Variational mode decomposition lies in solving variational problems. Let the original price series be f, assuming that f can be decomposed into K modal quantities, each modal has a limited bandwidth with a different center frequency, and the constraint to be satisfied is that the sum of each modal is equal to the original signal. The objective function for solving the variational problem is to minimize the sum of the bandwidth estimates of each mode (Li, et al., 2018).

Unlike traditional recursive mode decomposition such as EMD and LMD, VMD converts signal decomposition into non-recursive, variational modal decomposition. Its overall framework is a variational problem, which minimizes the sum of the bandwidth of each component after decomposition (Liu, et al., 2018).

In order to estimate the bandwidth of each modal component, we first need to perform Hilbert transform on each modal function to obtain its single-sided spectrum.

$$\left(\delta(t)+\frac{j}{\pi t}\right)\cdot\mu_k(t),\quad \delta(t)=\begin{cases}0, & t\neq 0\\ \infty, & t=0\end{cases} \tag{1}$$

Then, by adding an estimated center frequency $e^{j\omega_k t}$t, the frequency spectrum of each modal component is transformed to baseband;

$$\left[\left(\delta(t)+\frac{j}{\pi t}\right)\cdot\mu_k(t)\right]e^{j\omega_k t} \tag{2}$$

Finally, the square L^2 norm of the analytical signal gradient is calculated to estimate the bandwidth of each modal component.

Assuming that after the VMD decomposition, the original signal is decomposed into k modal components, the variational constraint model is:

$$\begin{cases}\min\limits_{\mu_k,\omega_k}\left\{\sum_k\left\|\partial_t\left[\left(\delta(t)+\frac{j}{\pi t}\right)\cdot\mu_k(t)\right]e^{-j\omega_k t}\right\|^2\right\}\\ s.t\sum_k\mu_k=f\end{cases} \tag{3}$$

among them: $\{\mu_k\}$——Collection of modal components, $\{\mu_k\}=\{\mu_1,\mu_2,\dots,\mu_k\}$;

$\{\omega_k\}$——Collection of center frequencies, $\{\omega_k\}=\{\omega_1,\omega_2,\dots,\omega_k\}$;

$\delta(t)$——Unit pulse function.

The VMD algorithm introduces the second penalty term α and Lagrange multiplier L to solve the above variational constraint model, that is:

$$L(\mu_k,\omega_k,\lambda)=\alpha\sum_k\left\|\partial_t\left[\left(\delta(t)+\frac{j}{\pi t}\right)\cdot\mu_k(t)\right]e^{-j\omega_k t}\right\|_2^2+\|f(t)-\sum_k\mu_k(t)\|_2^2+\langle\lambda(t),f(t)-\sum_k\mu_k(t)\rangle \tag{4}$$

The specific implementation steps of VMD are as follows:

Initialize $\{\hat{\mu}_k^1\}$, $\{\omega_k^1\}$, $\{\hat{\lambda}_k^1\}$ and n;

Make $n=n+1$, perform loop process.

Make $k=0, k=k+1$, update $\{\mu_k\}$, and $\{\omega_k\}$;

$$\hat{\mu}_k^{n+1}(\omega)=\frac{\hat{f}(\omega)-\sum_{i\neq k}(\omega)+\frac{\hat{\lambda}(\omega)}{2}}{1+2(\omega-\omega_k)^2} \tag{5}$$

$$\omega_k^{n+1}=\frac{\int_0^\infty\omega|\hat{\mu}_k(\omega)|^2d\omega}{\int_0^\infty|\hat{\mu}_k(\omega)|^2d\omega} \tag{6}$$

Update λ:

$$\hat{\lambda}^{n+1}(\omega)\leftarrow\hat{\lambda}^n(\omega)+\tau[\hat{f}(\omega)-\sum_k\hat{\mu}_k^{n+1}(\omega)] \tag{7}$$

where τ represents the noise tolerance parameter.

Repeat steps 2 to 4, until the condition of:

$$\frac{\sum_k\|\hat{\mu}_k^{n+1}-\hat{\mu}_k^n\|_2^2}{\|\hat{\mu}_k^n\|_2^2}<e \tag{8}$$

constraint is satisfied, the iteration is stopped.

2.3 Optimized VMD besed on SSA

To decompose the signal using VMD, it is necessary to preset the modal decomposition parameters such as the number of decompositions, penalty factors, fidelity coefficients, and convergence conditions. It is shown that the decomposition accuracy of VMD mainly depends on the decomposition number K and the penalty factor α. Too small a value of the decomposition number K will result in information loss; too large a value of K will lead to excessive decomposition (Hong, et al., 2011). The penalty parameter α affects the bandwidth of each modal component, and different bandwidth scales affect the extraction results of the signal. Due to the complexity and variability of the actual signal to be decomposed, it is more difficult to set the decomposition number K and penalty factor α artificially, and it tends to lead to the randomness of the decomposition results (Dragomiretskiy, 2014). For this reason, this paper proposes to optimize the parameters of VMD using SSA algorithm.

The fitness function of SSA to optimize VMD parameters adopts the energy difference tracking method proposed in the literature. The basic idea is to decompose the signal $f\ (t)$ into K limited bandwidth intrinsic mode functions (BIMF) u_i according to the VMD method, see equation (Chen, et al., 2004).

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$$f(t) = u_1(t) + u_2(t) + \cdots + U_k(t) = \sum_{i=1}^{k} u_i(t) \tag{9}$$

If the BIMF satisfies the orthogonality, the energy of the original signal $f(t)$ is equal to the energy sum of the K decomposed signals (see equation (10)).

$$E_{f1} = \int_{-\infty}^{+\infty} f^2(t)dt \tag{10}$$

$$E_{BIMF} = \int_{-\infty}^{+\infty} u_1(t)dt + \cdots + \int_{-\infty}^{+\infty} u_k(t)dt \tag{11}$$

$$E_{f1} = E_{BIMF} \tag{12}$$

When the actual decomposition components of the signal are not all orthogonal, there is an energy error E_{err} between E_{f1} and E_{BIMF}.

$$E_{err} = \left|E_{f1} - E_{BIMF}\right| \tag{13}$$

The smaller E_{err} is, the better the orthogonality of the decomposed BIMF components is, and the decomposition result can better characterize the signal $f(t)$.

The procedure for solving the optimal combination of parameters [K,α] for the VMD algorithm are as follows:

1) Setting the parameters of the SSA algorithm and the initial population, taking the energy error E_{err} as the fitness function.

2) Decompose the signal by VMD and the fitness value of each sparrow can be obtained by equation (8).

3) Updating the positions of individual sparrows according to the Sparrow Search Algorithm optimization mechanism, comparing the energy error E_{err} corresponding to each position, and continuously updating the minimum fitness value.

4) Iterating steps 2 to 4 in a loop until the global minimum fitness value is determined or the maximum number of iterations is reached and the optimal sparrow individual [K,α] is output.

5) VMD decomposition of the signal using the optimal parameters [K,α].

2.4 Optimal VMD

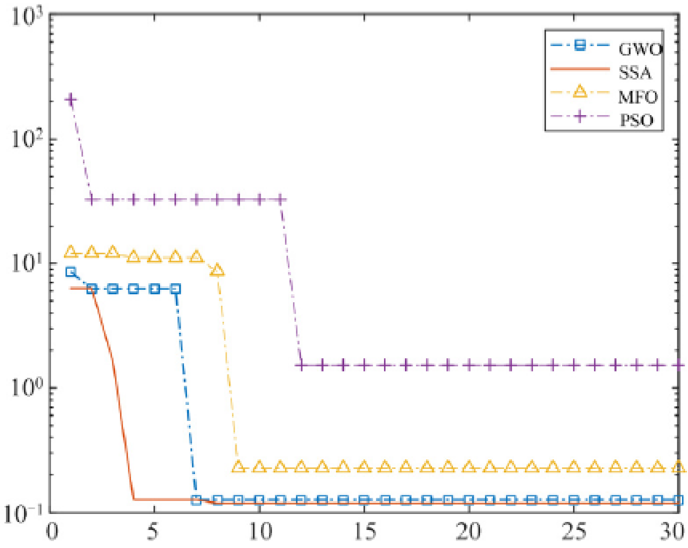
To verify the validity of the OVMD decomposition signal, a test signal y(t) is constructed, as shown in equation (14).

$$\begin{cases} y(t) = y_1(t) + y_2(t) + y_3(t) + y_4(t) \\ y_1(t) = \cos(100\pi t) \\ y_2(t) = 1.2\cos(200\pi t) \\ y_3(t) = 1.5 sincos(300\pi t) \end{cases} \tag{14}$$

where: y_4 is Gaussian noise with mean 0 and variance 0.2.

The number of SSA population is 20, the number of iterations is 30, the search range of K is [2,14], the search range of α is [0, 2000], and the parameter combination [K,α] of VMD after the SSA algorithm is [4,1837] with the minimum energy error of 0.497. The change curve of the optimal fitness value is shown in attached Figure 1. The SSA algorithm has the same better finding ability and adaptation compared with the other three algorithms.

Figure 1: Fitness change curves

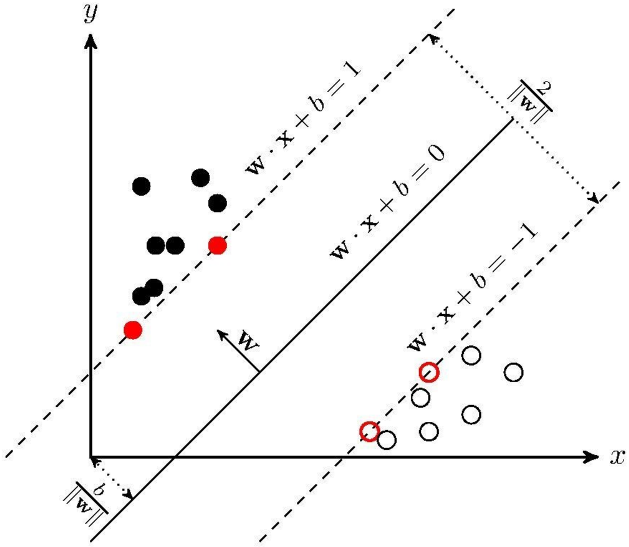


2.5 Support Vector Machine Model Prediction

Support vector machines are supervised learning models and related learning algorithms that analyze data in classification and regression analysis. Given a set of training instances, each labeled as belonging to one or the other of two categories. The SVM model represents instances as points in space, such that the mapping makes instances of individual classes separated by as wide a noticeable interval as possible. Then, map the new instances to the same space and predict the class they belong to based on which side of the interval they fall on.

The SVM training algorithm creates a model that assigns new instances to one of two classes, making it a non-probabilistic binary linear classifier. The learning strategy of SVM is to maximize the interval, which can be formalized as a problem of solving convex quadratic programming. It is also equivalent to the problem of minimizing the regularized hinge loss function. The learning algorithm of SVM is the optimal algorithm for solving convex quadratic programming. As shown in Figure 2 below, the $w \cdot x + b = 0$ is the separation hyperplane. For a linearly separable data set, there are infinitely many such hyperplanes (ie, perceptrons) but the separating hyperplane with the largest geometric interval is unique (Dragomiretskiy, 2014; Siami-Namini, et al, 2017).

Figure 2: Schematic diagram of SVM algorithm (source: GitHub)



The basic idea of SVM learning is to solve the separation hyperplane that can correctly divide the training data set and have the largest geometric interval. As shown below,$\boldsymbol{w} \cdot \boldsymbol{x} + \boldsymbol{b} = \boldsymbol{0}$ x is the separating hyperplane. For a linearly separable data set, there are infinitely number of such hyperplanes, but the separating hyperplane with the largest geometric interval is unique.

Assuming a training data set on the feature space is [13]:

$$T = \{(x_1, y_1), (x_2, y_2), \dots, (x_N, y_N)\} \tag{15}$$

Where $x_i \in R^n,$, $y_i \in \{+1, -1\}, i = 1,2, \dots, N$, x_i is the i th eigenvector. y_i is the type mark, when it is equal to +1, it is a positive example; when it is -1, it is a negative example. Also assume that the training data set is linearly separable.

For a given data set T and hyperplane $\boldsymbol{w} \cdot \boldsymbol{x} + \boldsymbol{b} = \boldsymbol{0}$, the geometric interval of the hyperplane with respect to the sample point (x_i, y_i) is defined as:

$$\gamma_i = y_i\left(\frac{w}{\|w\|} \cdot x_i + \frac{b}{\|w\|}\right) \tag{16}$$

the minimum value of the geometric interval of all sample points in the hyperplane is:

$$\gamma = \min_{i=1,2,\dots,N} \gamma_i \tag{17}$$

In fact, this distance is what we call the distance from the support vector to the hyperplane.

According to the above definition, the maximum split hyperplane problem of the SVM model can be expressed as the following constrained optimization problem.[8]

$$\max_{w,b} \gamma$$
$$s.t. \quad y_i\left(\frac{w}{\|w\|} \cdot x_i + \frac{b}{\|w\|}\right) \geq \gamma, i = 1,2, \dots, N \tag{18}$$

the constrained optimization problem can also be written as[13]:

$$\min_{w,b} \frac{1}{2}\|w\|^2$$
$$s.t. \quad y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) \geq \boldsymbol{1}, \boldsymbol{i} = \boldsymbol{1}, \boldsymbol{2}, \dots, \boldsymbol{N} \tag{19}$$

This is a convex quadratic programming problem with inequality constraints, and its dual problem can be obtained by using Lagrangian multiplier method. First, we convert the original constrained objective function into an unconstrained newly constructed Lagrangian objective function.

$$L(w, b, \alpha) = \frac{1}{2}\|w\|^2 - \sum_{i=1}^{N} \alpha_i (y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) - \boldsymbol{1}) \tag{20}$$

where α_i is the Lagrangian multiplier, and $\alpha_i \geq \boldsymbol{0}$. Now we make

$$\theta(w) = \max_{\alpha_i \geq 0} L(w, b, \alpha) \quad (21)$$

when the sample point does not meet the constraints, that is, outside the feasible solution area:

$$y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) < \boldsymbol{1} \quad (22)$$

At this time, if α_i is set to infinity, then $\theta(w)$ is also infinity.
When the sample point satisfies the constraint condition, that is, in the feasible solution area:

$$y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) \geq \boldsymbol{1} \quad (23)$$

At this time, $\theta(w)$ is the original function itself. Therefore, we can get our new objective function by combining the two cases:

$$\theta(w) = \begin{cases} \frac{1}{2}\|w\|^2, & x \in \text{feasible solution area} \\ +\infty, x \in \textit{non}\text{feasible solution area} \end{cases} \quad (24)$$

so the original constraint problem is equivalent to:

$$\min_{w,b} \theta(w) \ = \min_{w,b} \max_{\alpha_i \geq 0} L(w, b, \alpha) = p^* \quad (25)$$

Here we need to use the duality of the Lagrangian function to exchange the minimum and maximum positions, so that it becomes:

$$\max_{\alpha_i \geq 0} \min_{w,b} L(w, b, \alpha) = d^* \quad (26)$$

To have $p^* = d^*$, two conditions need to be met (Cryer,et al., 2008) :

1. The optimization problem is a convex optimization problem.
2. Meet KKT conditions.

First of all, the optimization problem here is obviously a convex optimization problem, so condition one is satisfied. And to meet the second condition is the requirement:

$$\begin{cases} \alpha_i \geq 0 \\ y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) - \boldsymbol{1} \geq \boldsymbol{0} \\ \alpha_i(y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) - \boldsymbol{1}) = \boldsymbol{0} \end{cases} \quad (27)$$

In order to obtain the specific form of solving the dual problem, let the partial derivative of $L(w, b, \alpha)$ to $\boldsymbol{w}$ and b be 0, can get:

$$\boldsymbol{w} = \sum_{i=1}^{N} \alpha_i y_i \boldsymbol{x_i} \quad (28)$$

$$\sum_{i=1}^{N} \alpha_i y_i = \boldsymbol{0} \quad (29)$$

Bringing the above two equations into the Lagrangian objective function, eliminating $\boldsymbol{w}$ and $\boldsymbol{b}$, get:

$$L(w, b, \alpha) = \frac{1}{2}\sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j y_i y_j (\boldsymbol{x_i}.\boldsymbol{x_j}) - \sum_{i=1}^{N} \alpha_i y_i ((\sum_{j=1}^{N} \alpha_j y_j \boldsymbol{x_j}).\boldsymbol{x_i} + \boldsymbol{b}) + \sum_{i=1}^{N} \alpha_i \quad (30)$$

That is,

$$\min_{w,b} L(w, b, \alpha) = -\frac{1}{2}\sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j y_i y_j (\boldsymbol{x_i}.\boldsymbol{x_j}) + \sum_{i=1}^{N} \alpha_i \quad (31)$$

Finding the extrema of $\min_{w,b} L(w, b, \alpha)$ to α is a dual problem:

$$\max_{\alpha} -\frac{1}{2}\sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j y_i y_j (\boldsymbol{x_i}.\boldsymbol{x_j}) + \sum_{i=1}^{N} \alpha_i$$
$$s.t. \sum_{i=1}^{N} \alpha_i y_i = \boldsymbol{0} \quad (32)$$
$$\alpha_i \geq 0, i = 1,2, \dots, N$$

Adding a minus sign to the objective expression to convert the maximum value to the minimum value:

$$\text{mix}_{\alpha} \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j y_i y_j (\boldsymbol{x_i}.\boldsymbol{x_j}) - \sum_{i=1}^{N} \alpha_i$$
$$s.t. \sum_{i=1}^{N} \alpha_i y_i = \boldsymbol{0} \quad (33)$$
$$\alpha_i \geq 0, i = 1,2, \dots, N$$

The optimization problem now becomes the above form. We can get the α^* through this optimization algorithm, and then according to the α^*, we can solve the w and b, and then get our original goal: to find the hyperplane, that is, the decision plane

The previous derivations are all established under the assumption that the KKT condition is satisfied, and the KKT condition is as follows,

$$\begin{cases} \alpha_i \geq 0 \\ y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) - \boldsymbol{1} \geq \boldsymbol{0} \\ \alpha_i(y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) - \boldsymbol{1}) = \boldsymbol{0} \end{cases} \tag{34}$$

In addition, according to the previous derivation, the following two formulas hold:

$$\boldsymbol{w} = \sum_{i=1}^{N} \alpha_i^* y_i \boldsymbol{x_i} \tag{35}$$

$$b^* = y_i - \sum_{i=1}^{N} \alpha_i^* y_i (\boldsymbol{x_i} \cdot \boldsymbol{x_j}) \tag{36}$$

For any training sample (x_i, y_i), there is always $\alpha_i = 0$ or $y_i(w \cdot x_i + b) = 1$. If $\alpha_i = 0$, the sample will not appear in the final formula for solving the model parameters. If $\alpha_i > 0$, there must be $y_i(w \cdot x_i + b) = 1$, the corresponding sample point is located on the boundary of the maximum interval and is a support vector. This shows an important property of the support vector machine: after the training is completed, most of the training samples do not need to be retained, and the final model is only related to the support vector.

So far, it is based on the assumption that the training set data is linearly separable, but in reality, there is almost no completely linearly separable data. In order to solve this problem, the concept of "soft interval" is introduced, which allows certain points not to satisfy the constraint:

$$y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) \geq \boldsymbol{1} \tag{37}$$

so the hinge loss is used to rewrite the original optimization problem as:

$$\begin{gathered} \min_{w,b,\xi_i} \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{m} \xi_i \\ s.t.\, y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}) \geq \boldsymbol{1} - \xi_i \\ \xi_i \geq \boldsymbol{0}, \boldsymbol{i} = \boldsymbol{1}, \boldsymbol{2}, \ldots, \end{gathered} \tag{38}$$

where ξ_i is the slack variable, $\xi_i = \max(0, 1 - y_i(\boldsymbol{w} \cdot \boldsymbol{x_i} + \boldsymbol{b}))$ is a hinge loss function. Each sample has a corresponding slack variable, which represents the degree to which the sample does not meet the constraints. $C > 0$ is called the penalty parameter. The larger the value of C, the greater the penalty for classification. Consistent with the linear separable solution, the Lagrangian function is obtained by using the Lagrangian multiplier method, then solve the dual problem.

Based on the above discussion, we can get the linear support vector machine learning algorithm as follows:

Input: training data set $T = \{(x_1, y_1), (x_2, y_2), \ldots, (x_N, y_N)\}$, where;

Output: Separate hyperplane and classification decision function

Choose the penalty parameter C>0, construct and solve the convex quadratic programming problem

$$\begin{gathered} \operatorname{mix}_{\alpha} \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j y_i y_j (\boldsymbol{x_i} \cdot \boldsymbol{x_j}) - \sum_{i=1}^{N} \alpha_i \\ s.t.\, \sum_{i=1}^{N} \alpha_i y_i = \boldsymbol{0} \\ 0 \leq \alpha_i \leq C, i = 1,2, \ldots, N \end{gathered} \tag{39}$$

Get the optimal solution $\alpha^* = (\alpha_1^*, \alpha_2^*, \ldots, \alpha_N^*)^T$

Calculate

$$\boldsymbol{w}^* = \sum_{i=1}^{N} \alpha_i^* y_i \boldsymbol{x_i} \tag{40}$$

Choose a component α_j^* of α^* that satisfies the condition $0 \leq \alpha_j^* \leq C$ and calculate

$$b^* = y_i - \sum_{i=1}^{N} \alpha_i^* y_i (\boldsymbol{x_i} \cdot \boldsymbol{x_j}) \tag{41}$$

Find the separating hyperplane

$$\boldsymbol{w}^* \cdot \boldsymbol{x} + b^* = \boldsymbol{0} \quad (42)$$

The classification decision function here is:

$$f(x) = sign(\boldsymbol{w}^* \cdot \boldsymbol{x} + b^*) \quad (43)$$

For the nonlinear classification problem in the input space, it can be transformed into a linear classification problem in a certain dimensional feature space by nonlinear transformation. In this way, linear support vector machines can be learned in the high-dimensional feature space. Since in the dual problem of linear support vector machine learning, both the objective function and the classification decision function only involve the inner product between the instance and the instance. So there is no need to explicitly specify the non-linear transformation, but replace the inner product with the kernel function (Xue, et al., 2020). The kernel function represents the inner product between two instances after a nonlinear transformation. Specifically, $K(x,z)$ is a function or positive definite kernel, which means that there is a mapping from the input space to the feature space $\phi(x)$. For x, z in any input space, there is:

$$K(x,z) = \phi(x) \cdot \phi(z) \quad (44)$$

In the dual problem of linear support vector machine learning, the kernel function $K(x,z)$ is used to replace the inner product, and the solution obtained is a nonlinear support vector machine:

$$f(x) = sign(\sum_{i=1}^{N} \alpha_i^* y_i K(\boldsymbol{x} \cdot \boldsymbol{x}_i) + b^*) \quad (45)$$

Based on the above discussion, we can get the non-linear support vector machine learning algorithm as follows:

Input: training data set $T = \{(x_1, y_1), (x_2, y_2), \ldots, (x_N, y_N)\}$, where $x_i \in R^n, , y_i \in \{+1, -1\}, i = 1,2, \ldots, N$;

Output: Separate hyperplane and classification decision function

Choose an appropriate kernel function $K(x,z)$ and penalty parameter $C > 0$, construct and solve the convex quadratic programming problem:

$$\begin{gathered} \underset{\alpha}{\text{mix}} \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j y_i y_j K(\boldsymbol{x} \cdot \boldsymbol{x}_j) - \sum_{i=1}^{N} \alpha_i \\ s.t. \sum_{i=1}^{N} \alpha_i y_i = \boldsymbol{0} \\ 0 \leq \alpha_i \leq C, i = 1,2, \ldots, N \end{gathered} \quad (46)$$

Get the optimal solution $\alpha^* = (\alpha_1^*, \alpha_2^*, \ldots, \alpha_N^*)^T$

Calculate: choose a component α_j^* of α^* that satisfies the condition $0 \leq \alpha_j^* \leq C$ and calculate

$$b^* = y_i - \sum_{i=1}^{N} \alpha_i^* y_i K(\boldsymbol{x} \cdot \boldsymbol{x}_j) \quad (47)$$

Classification decision function:

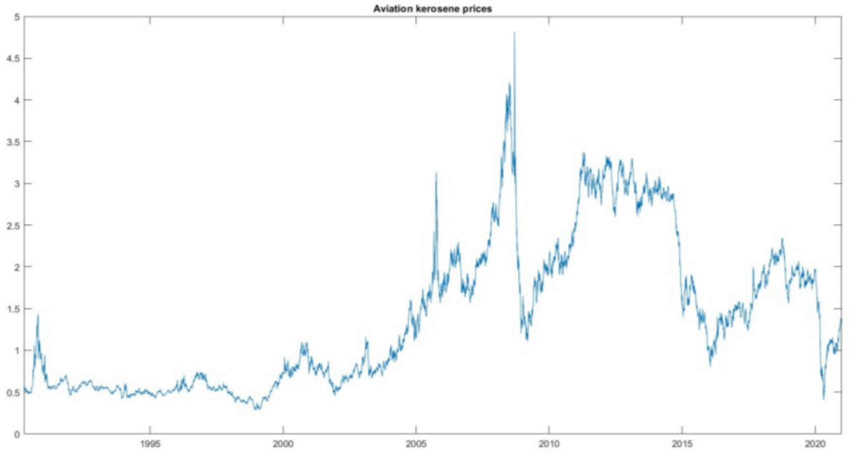
$$f(x) = sign(\sum_{i=1}^{N} \alpha_i^* y_i K(\boldsymbol{x} \cdot \boldsymbol{x}_i) + b^*) \quad (48)$$

3. Case study: prices forecast based on the optimized VMD and SVM model

In this chapter, we will use the compound optimization VMD-SVM model to analyze and predict the aviation kerosene price time series. In the jet fuel price forecast, we will use the U.S. Gulf Coast kerosene jet fuel price data[3] from January 1, 1990 to December 31, 2020, the last closing day for jet fuel prices, see Figure 3. The training set and test set are split in a ratio of 8:2.

[3] www.IATA.com

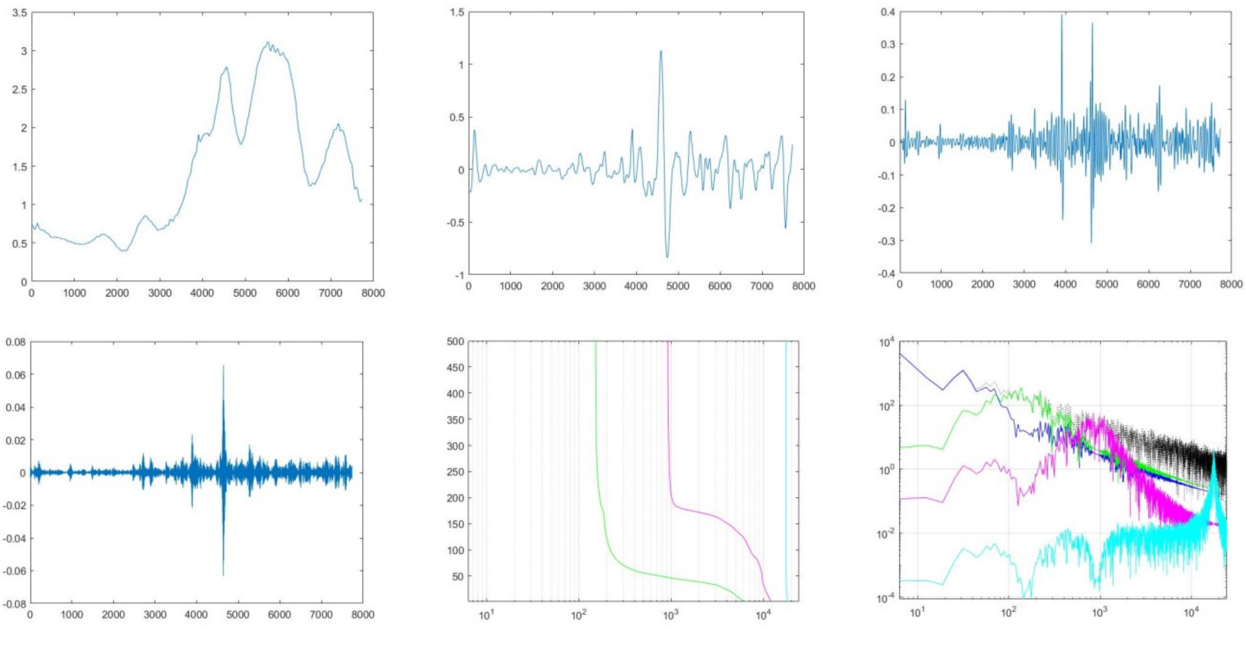
Figure 3 Historical data of aviation kerosene fuel price (data source: IATA)



3.1 Sequence decomposition of aviation kerosene prices

When decomposing the sample sequence, the method in Section 2.1 is used to set the OVMD parameters: the penalty parameter α is 1837; the number of modal functions is K=4; the other parameters are all default values. The decomposition results are shown in Figure 4. It can be seen from the figure that IMF1 has the largest proportion among the four components, IMF2 and IMF3 have the middle proportion, and IMF4 has the smallest proportion, and the frequencies of IMF1-IMF4 increase sequentially.

Figure 4 VMD result of aviation kerosene data



In VMD decomposition, the information of the data is also mainly included in the middle and low frequency decomposition results, which can be obtained from the statistical analysis of the subscripted VMD results shown in Table 1.

Table 1 Descriptive statistics of aviation kerosene data VMD result

	PCC	STDEV	Max	Min	Median	Kurtosis	Skewness
imf1	0.9716	0.8465	3.1160	0.3967	1.2476	-1.0356	0.5419
imf2	0.3191	0.1916	1.1284	-0.8386	-0.0051	10.5672	0.8734
imf3	0.0931	0.0465	0.3906	-0.3086	-0.0003	12.5361	0.7409
imf4	0.0099	0.0042	0.0655	-0.0631	0.0000	45.3763	-0.0050

3.2 OVMD-SVM model to forecast aviation kerosene price

Previous studies have confirmed that different kernel functions have little effect on the prediction performance of support vector machines, but the choice of kernel function parameters seriously affects the generalization ability of support vector machines. Judging from the existing research results, the most commonly used kernel function, the Gaussian kernel function, has obtained a good prediction effect in most cases. Therefore, this study mainly uses the Gaussian kernel function based on the previous research. Therefore, the model has two parameters that need to be tuned, namely the parameter σ of the Gauss kernel function and the penalty parameter C used when the model is optimized. In our empirical example, the optimal combination of these two parameters was confirmed after enumeration.

By sequentially performing SVM prediction on the four IMF results decomposed by the above VMD, the following results can be obtained. After the parameters of each part of the OVMD-SVM model are determined, first use the model to predict each IMF component, and then superimpose the prediction results of each component as the final result of price prediction. The prediction results are shown in Figure 5 and Figure 6.

Figure 5 SVM forecast result of IMF 1 to IMF 4

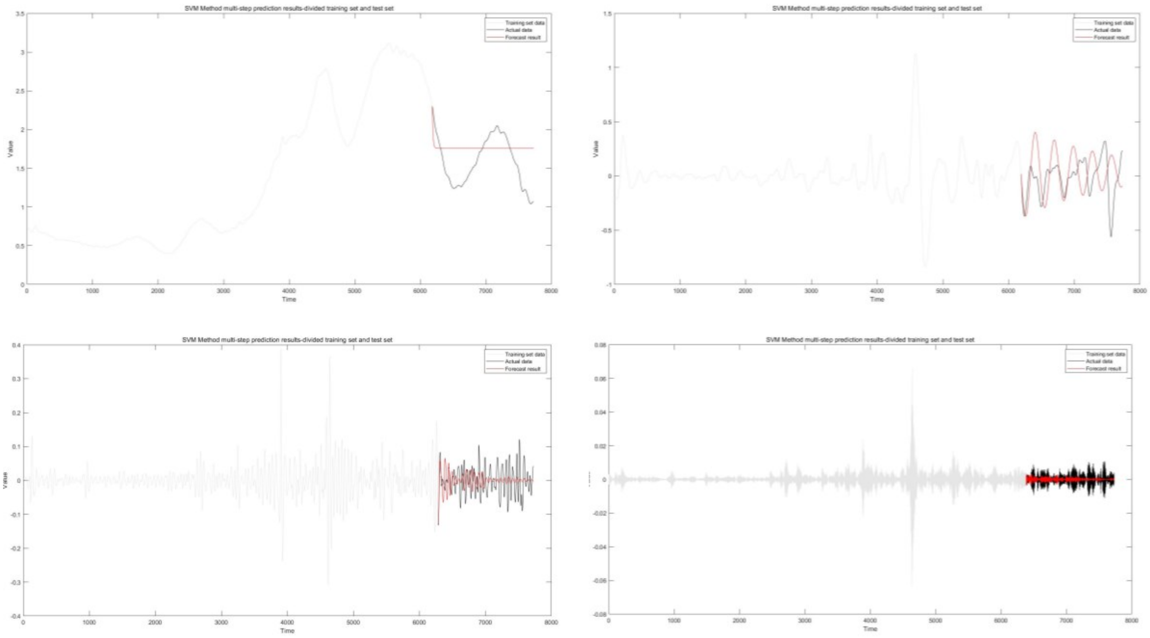
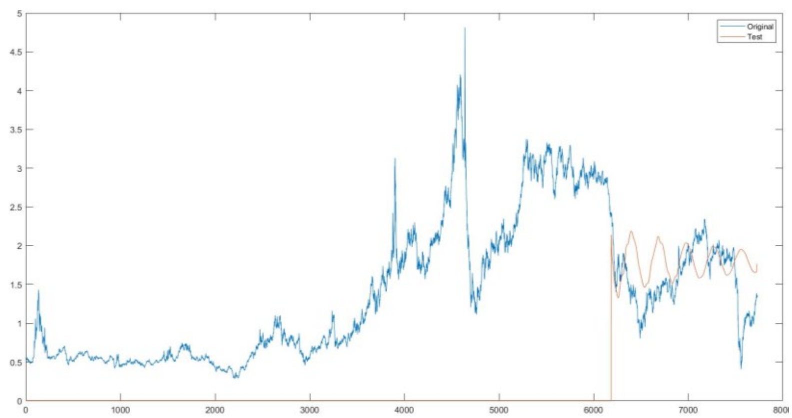


Figure 6 Optimized VMD-SVM forecast test result of aviation kerosene price



3.3 Prediction models reults comparison

In order to prove the feasibility of the method in this paper, the conventional methods of commodity futures price prediction including ARIMA model, LSTM neural network, and EMD method and their combined models are compared with the method in this paper. In order to ensure the objectivity, the parameters of each prediction model are selected through multiple trials and experiments to select the best value. In this part, we will select the best prediction model for aviation kerosene price based on the MSE, RMSE and other indices obtained when the model was tested in the previous part.

First of all, in the fuel price prediction model indices in the following table, we can conclude that the best model in terms of fuel price prediction accuracy is LSTM, followed by VMD-SVM model. However, when we made a longitudinal comparison of the four indicators of MSE, RMSE, MAE and MAPE shown in Table 2, we found that the indicator values of the LSTM results were significantly deviated from the result intervals of other models, and there may be over-fitting. Therefore, this paper will use the OVMD-SVM model as the optimal prediction model

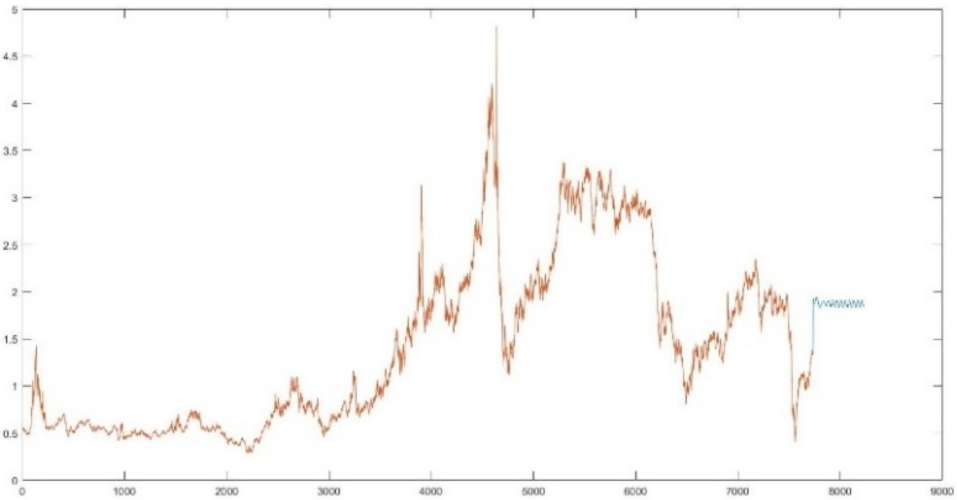
Table 2 Comparison of results of fuel price prediction models

Prediction model	MSE	RMSE	MAE	MAPE
ARMA	0.534	0.731	0.634	0.618
EMD-ARMA	0.510	0.714	0.631	0.556
LSTM	0.004	0.061	0.087	0.076
EMD-SVM	0.425	0.652	0.682	0.413
OVMD-SVM	0.273	0.522	0.357	0.346

3.4 Optimized VMD-SVM model forecasting of aviation kerosene price

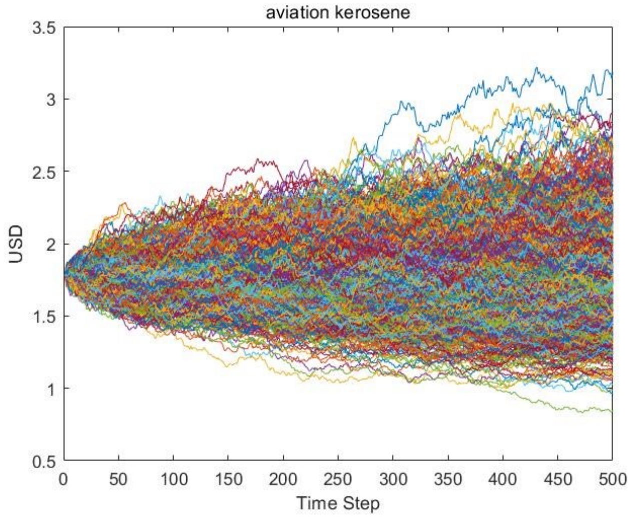
After verifying the feasibility of the Optimized VMD-SVM model composite model and comparing the accuracy, we will use the model to forecast the aviation kerosene price data in 2021 and 2022.

Figure 7 Optimized VMD-SVM forecast result of aviation kerosene price from 2021 to 2022



From the perspective of risk analysis research, a single price series forecast is not enough for further research. We also need to perform a further simulation of the forecast results that have been obtained, here we will use the volatility of the forecast results to perform a Monte Carlo simulation. The step size of the simulation is 500 steps and the number of simulations is 1000. The simulation results are shown in Figure 8 below. On the basis of this simulation result, we can conduct further research and analysis on the market risk caused by the fluctuation of aviation kerosene price.

Figure 8 Simulation result of Optimized VMD-SVM forecast of aviation kerosene price from 2021 to 2022



4. Conclusion

Support vector machines have a wide range of application prospects in the prediction of non-linear systems because of their wide adaptability and learning ability. Market price forecasting is a nonlinear modeling problem, but there is still a lack of systematic research on support vector machines in price forecasting. This paper makes some attempts in this regard, further excavates the support vector machine method, and applies it to price prediction, and obtains basically satisfactory results.

In order to improve the accuracy of aviation kerosene price forecasting, this paper proposes the OVMD-SVM combined forecasting model, analyzes the actual price data as an example, and draws the following conclusions:

1) The SSA algorithm is superior to GWO, PSO and MFO algorithms in terms of solution accuracy and stability and can be used to optimize the main parameters such as the decomposition number K and penalty factor α of VMD, and the OVMD method has better performance on the original signal than the EMD method. decomposition effect.
2) The analysis shows that the prediction effect of the OVMD-SVM combination model is better than that of the EMD-SVM combination prediction method, and both are better than the single SVM method.
3) For time series data prediction, the prediction effect of OVMD-SVM model is better than that of ARIMA, LSTM and other methods.

Compared with a single prediction model, the new combined data preprocessing algorithm provides better prediction accuracy to a certain extent, whether in short-term or long-term prediction. Therefore, the new price prediction algorithm based on OVMD for data preprocessing has a certain application value in aviation kerosene price prediction.

The physical signal processing models preprocessing data have achieved good precision in the prediction of financial time series. There is great uncertainty in the field of financial forecasting, because of the rapid uncertainty of the market. Combining the rigorous science and technology model with high accuracy requirements it can effectively improve the accuracy of prediction and reduce unnecessary risks.

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Influence of ROIC Convergence Process on Company's Value

Petr Gurný[1], Dalibor Wachtarczyk[2]

Abstract

In this paper, we analyse an influence of the return on invested capital (ROIC) convergence process on a company's value within two stages discounted cash flow model. The goal of the paper is to violate simplified and unrealistic assumption of jump change of the ROIC between first and second stage. Under the assumption that the current level of the ROIC is different from its sustainable level, we investigate influence of the stochastic mean-reversion process on a company's value. For simplification, ROIC convergence is the only parameter, which determined the length of first stage in this paper. Sensitivity analysis on chosen parameters of the model is also performed. As a result, the importance of the convenient ROIC convergence function is demonstrated.

Key words

Company's valuation; multi-stage DCF model; return on invested capital modelling.

JEL Classification: G12; G32

1. Introduction

In this paper, we will deal with the convergence process of one of the key parameters when estimating the value of a company, return on invested capital (ROIC). Especially when using multi-phase valuation methods, it often happens that the value of the key value generators is different from the long-term sustainable level. These value generators are primarily growth rate, return on invested capital and required rate of return. Especially in the case of the growth rate and profitability of capital, in practice there is often a simplifying assumption that the abnormal level of these parameters will jump back to a long-term sustainable level after a certain period of time. However, this approach is not theoretically correct, because a sudden change in these parameters will probably not be economically justifiable. A more realistic assumption is a gradual convergence to a sustainable level. In this paper, we will work with basic two-stage DCF model. In this paper, we analyse an influence of the return on invested capital (ROIC) convergence process on a company's value within two stages discounted cash flow model. The goal of the paper is to violate simplified and unrealistic assumption of jump change of the ROIC between first and second stage. Under the assumption that the current level of the ROIC is different from its sustainable level, we investigate influence of the stochastic mean-reversion process on a company's value. For simplification, ROIC convergence is the only parameter, which determined the length of first stage in this paper. Sensitivity analysis on chosen parameters of the model is also performed.

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2. Literature review

The basic model in this area was firstly proposed by Gordon (1962). This model was so called one-stage model and it was based on constant dividend (free cash flow, FCF) growth rate. This model is pretty simple and straightforward, since it requires only estimates of two parameters (FCF growth rate and discount rate). Nevertheless, it also has some serious limitations. It is suitable only for companies with a long run stable FCF. Moreover, the assumption of constant growth rate of the FCF forever is not realistic. A lot of models were introduced to relax this simplified assumption. As a main work in this area, we can consider the research of Malkiel (1963), where two-stage model was introduced. This model has first *n* years of extraordinary growth followed by a stable growth forever. It means, that value of asset can be obtained as the sum of first stages present values plus a discounted value of the general Gordon growth model at year *n*. This model is suitable for valuing companies, which expect to have higher (or lower) a growth rate in initial (first) stage than normal (long term, sustainable) growth rate. This can occur because of a specific investment or patent right, that can result in higher profit, or just because of a stage of a company's life cycle. Limit of this model is in the sharp drop (rise) of a growth rate from the first to second (stable) stage. To avoid this limitation, Fuller and Hsia (1984) propose an H-model, which works with a linear decline of the growth rate. This model was of fundamental importance especially in the precomputing era, as it reduced the number of parameters while maintaining the analytical solution. However, the result of the model was only an approximation. Comparison analysis of the difference in the company's values while using of classical two stages model and model with chosen growth rate function (linear, quadratic, logarithmic and exponential function) in first stage is discussed in Gurný and Sedláková (2021). Here, the importance of the convenient growth rate function depending on the length of the first stage is also demonstrated. We can also mention here a three-stages DCF models, which can estimate an asset's value more precisely, however it requires a larger number of inputs. An empirical comparison of the basic Gordon model and its variations can be found in Sorensen and Williamson (1985). Conclusions of this work suggest that the increased complexity of the model improves the results (the 3-stage model shows the best results). Some other extensions were proposed by Brooks and Helms (1990), who propose an N-stages model with quarterly FCF and fractional period, Barsky and De Long (1993), who propose a model with permanent growth calculated as geometric average of past FCF changes, or Donaldson and Kamstra (1996), who worked with a Monte Carlo simulation and numerical integration of random joint process of FCF growth and discount rate. Extended reviews of the basic DCF model and its extensions can be found in Kamstra (2003) and Damodaran (2012).

3. Literature review

We will start with the basic one-stage valuation DCF model proposed by Gordon (1962):

$$V=\sum_{t=1}^{\infty}\frac{FCF\cdot\left(1+g\right)^{t-1}}{\left(1+R\right)^{t}}=\frac{FCF}{R-g}, \tag{1}$$

where V is the value of an asset, t is particular period, g is constant growth rate and R is discount rate.[3]

Assuming that the expected lifetime of an asset can be divided into two phases according to the FCF growth rate, the value of an asset can generally be estimated as:

[3] For simplification, we will assume that *R (WACC)* is lower than *g* for the whole paper.

$$V = FCF_0 \cdot \left\{ \sum_{t=1}^{T} \frac{\prod_{i=1}^{t} \left(1+g(i)\right)}{\left(1+R\right)^t} + \frac{\left[\prod_{i=1}^{T} \left(1+g(i)\right)\right] \cdot \left(1+g_B\right)}{\left(R-g_B\right) \cdot \left(1+R\right)^T} \right\}, \tag{2}$$

where FCF_0 is initial free cash flow in time 0, T is length of the first stage, i is particular period in the first stage, $g(i)$ is a growth rate function in first stage and g_B is sustainable growth rate in second stage. If we will assume that $g(i) = g_A$, where g_A is a constant growth rate in the first stage, we can rewrite (2) as:

$$V = FCF_0 \cdot \left[\sum_{t=1}^{T} \left(\frac{1+g_A}{1+R} \right)^t + \frac{\left(1+g_A\right)^T \cdot \left(1+g_B\right)}{\left(R-g_B\right) \cdot \left(1+R\right)^T} \right] \tag{3}$$

and after some rearrangements we can get Malkiel (1963) two-stage valuation formula:

$$V = FCF_0 \cdot \left(\frac{1+g_A}{R-g_A} \right) \cdot \left[1 - \left(\frac{1+g_A}{1+R} \right)^{T-1} \cdot \frac{\left(g_A - g_B\right)}{\left(R-g_B\right)} \right]. \tag{4}$$

Recall that in (4) we have a jump change between g_A and g_B in time T, which is an unrealistic assumption in real world.

If we consider entity level of value and if we replace *FCF* in the basic equation (2) by key value driver formula (see Koller (2020) for more detail), we have

$$V = NOPAT_0 \left\{ \sum_{t=1}^{T} \frac{\prod_{i=1}^{t} \left(1+g(i)\right) \cdot \left(1 - \frac{g(t)}{ROIC(t)}\right)}{\left(1+WACC(t)\right)^t} + \frac{\prod_{i=1}^{T} \left(1+g(i)\right) \cdot \left(1+g_B\right) \left(1 - \frac{g_B}{ROIC_B}\right)}{\left(WACC_T - g_B\right) \cdot \left(1+WACC_T\right)^T} \right\}, \tag{5}$$

where $NOPAT(\cdot)$ is net operational profit after tax, $WACC(\cdot)$ is weighted average cost of capital (where $WACC_T$ denotes required rate of return in first year of second stage) and $ROIC(\cdot)$ is return on invested capital (where $ROIC_B$ denotes sustainable *ROIC* in second stage).

There are several ways to deal with convergence processes in the case of *g* and *ROIC*. We can estimate the key parameters of the process (sustainable level and length of the first phase) by expert estimation. Here, we mostly model convergence according to a monotonic function. E.g., for rate of growth *g*, if we assume logarithmic function $g(i) = a \cdot \ln(i+b) + c$, then after estimating parameters, we get $g(i) = \frac{g_B - g_A}{\ln\left(\frac{T}{b}+1\right)} \cdot \ln\left(\frac{i}{b}+1\right) + g_A$ for $b \in \left(0;\infty\right\rangle$. After substituting $g(i)$ into the (2), we obtain following valuation formula (see Gurný and Sedláková (2021) for more detail):

$$V = FCF_0 \cdot \left\{ \sum_{t=1}^{T} \frac{\prod_{i=1}^{t} \left[1 + \frac{g_B - g_A}{\ln\left(\frac{T}{b}+1\right)} \cdot \ln\left(\frac{i}{b}+1\right) + g_A \right]}{(1+R)^t} + \frac{\left\{ \prod_{i=1}^{T} \left[1 + \frac{g_B - g_A}{\ln\left(\frac{T}{b}+1\right)} \cdot \ln\left(\frac{i}{b}+1\right) + g_A \right] \right\} \cdot (1+g_B)}{(R-g_B)\cdot(1+R)^T} \right\} \quad (6)$$

The disadvantage of this approach is a subjective view. An alternative to this model can be, for example, the heuristic Weiler model, see Weiler (2005).

In this paper, we consider $g(t)$, $ROIC(t)$ and $WACC(t)$ to be a random process, where $g(t)$ and $WACC(t)$ will be modelled by random walk: $x_t = x_{t-1}\exp\left(\sigma \cdot \tilde{z} \cdot \sqrt{\Delta t}\right)$, where $x_{(\cdot)}$ is modelled variable, σ is relative standard deviation and $\tilde{z}$ is a random variable from the standard normal distribution $N(0;1)$. Key attention will then be paid to *ROIC*, which we will model using Vasicek discrete mean-reversion process:

$$dx = a \cdot (b - x) \cdot dt + \sigma \cdot \tilde{z} \cdot \Delta t, \quad (7)$$

where *a* denotes velocity and *b* long-term mean (sustainable level). In this article, we will use a simulation version of this process:

$$x_t = x_{t-\Delta t} \cdot \exp(-a \cdot \Delta t) + b \cdot (1 - \exp(-a \cdot \Delta t)) + \sigma \cdot \sqrt{\frac{(1 - \exp(-2a \cdot \Delta t))}{2a}} \cdot \tilde{z} \cdot \sqrt{\Delta t} \ . \quad (8)$$

4. Illustrative applications

We will demonstrate a convergence effect of *ROIC* in the first stage using an illustrative example. As is clear from (5), in the case of the valuation model, the determination of value is given by seven variables: $NOPAT_0$, g_B, $ROIC_B$, $WACC(t)$, $g(t)$, $ROIC(t)$, T. The sustainable long-term input data for the illustrative example are recorded in Table 1:

Table 1: Sustainable long-term input data

$NOPAT_0$	g_B	$ROIC_B$
3 900	0.034	0.25

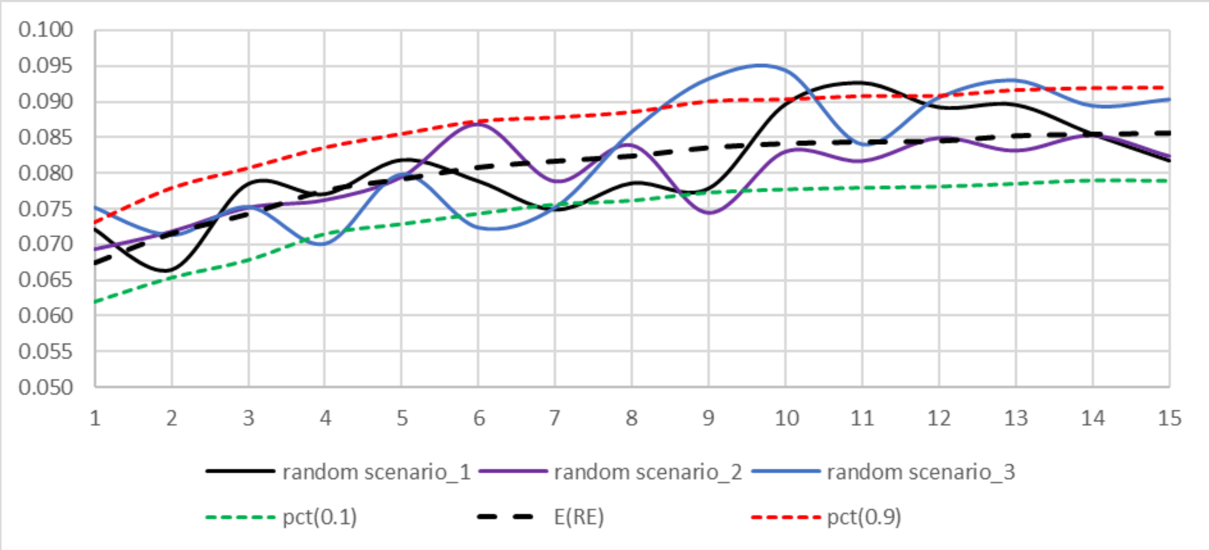
Weighted average cost of capital (required rate of return $WACC(t)$) is based on estimation of cost of debt, R_D, and cost of equity, R_E. The weights were determined on the basis of an iterative procedure in order to align the estimated capital structure with the market capital structure. R_D was estimated on 0.027. R_E was estimated according CAPM with the $\beta = 1.13$. Estimated risk-free rate for next 15 years, R_F, is depicted in Table 2, whereas $R_{F(T)} = 0.022$.

Table 2: Estimated Risk-free rate

TTM	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
R_F	0.0011	0.0024	0.0038	0.0065	0.008	0.0094	0.0102	0.0109
TTM	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*T*
R_F	0.012	0.0127	0.013	0.0133	0.0136	0.0138	0.0141	0.022

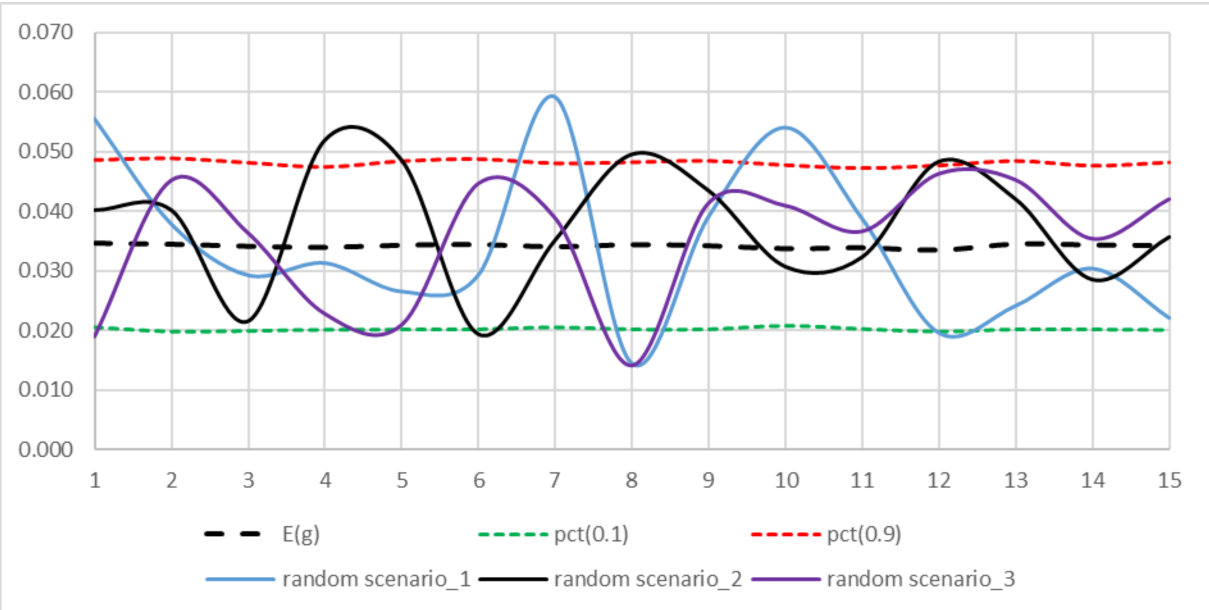
Equity risk premium (*ERP*) was simulated via random walk with $ERP_0 = 0,063$ and $\sigma = 0,0056$. Estimated R_E can be observed in Figure 1.

Figure 1: Estimated R_E



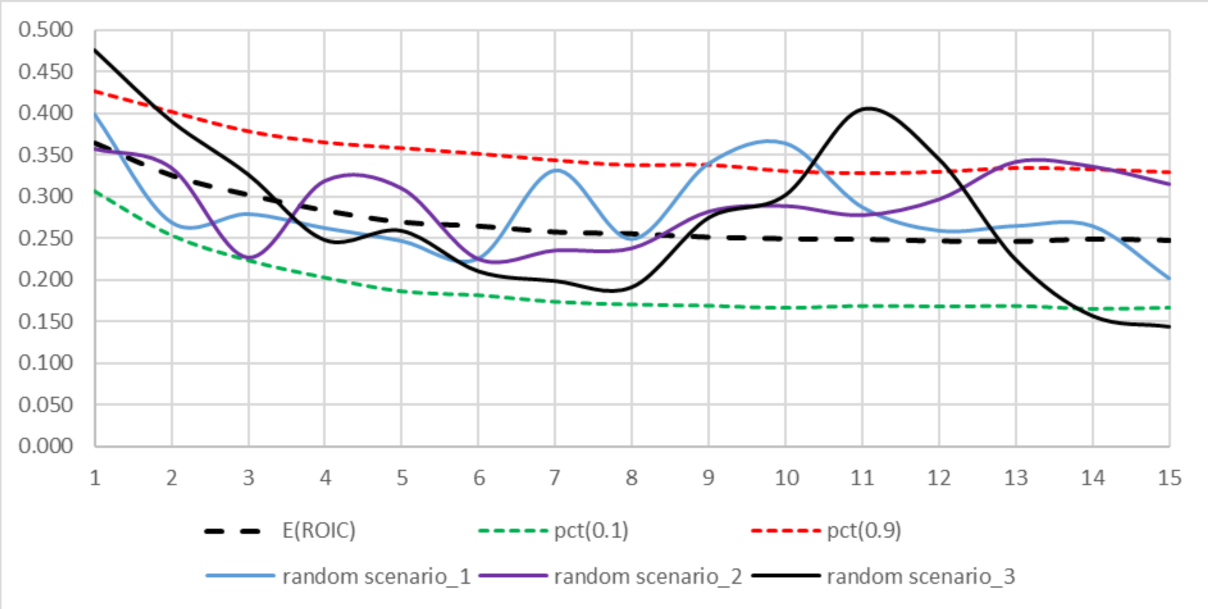
Rate of growth for given period, $g(t)$, was simulated via random walk with $g_0 = 0,063$ and $\sigma = 0,011$. Estimated $g(t)$ can be observed in Figure 2.

Figure 2: Estimated $g(t)$



To capture the $ROIC(t)$ convergence process, we used the simulation version of the Vasicek discrete mean-reversion process, as described in (8). The estimated parameters are as follows: $a = 0.4$, $b = 0.25$ (long-term sustainable level of *ROIC*), $\sigma = 0.0575$, $ROIC_0 = 0.42$. Estimated $ROIC(t)$ can be observed in Figure 3.

Figure 3: Estimated $ROIC(t)$



Length of the first stage, T, is usually determined based on an expert estimate and is the same for all scenarios. In this paper, however, we consider $ROIC(t)$ stabilization to be the beginning of the second stage. For this reason, the length of the first stage varies for each scenario. Thus, the second phase in each scenario begins when the $ROIC(t)$ approaches less than 5% of the long-term sustainable $ROIC(t)$. The maximum length of the first stage is set at 15 years.

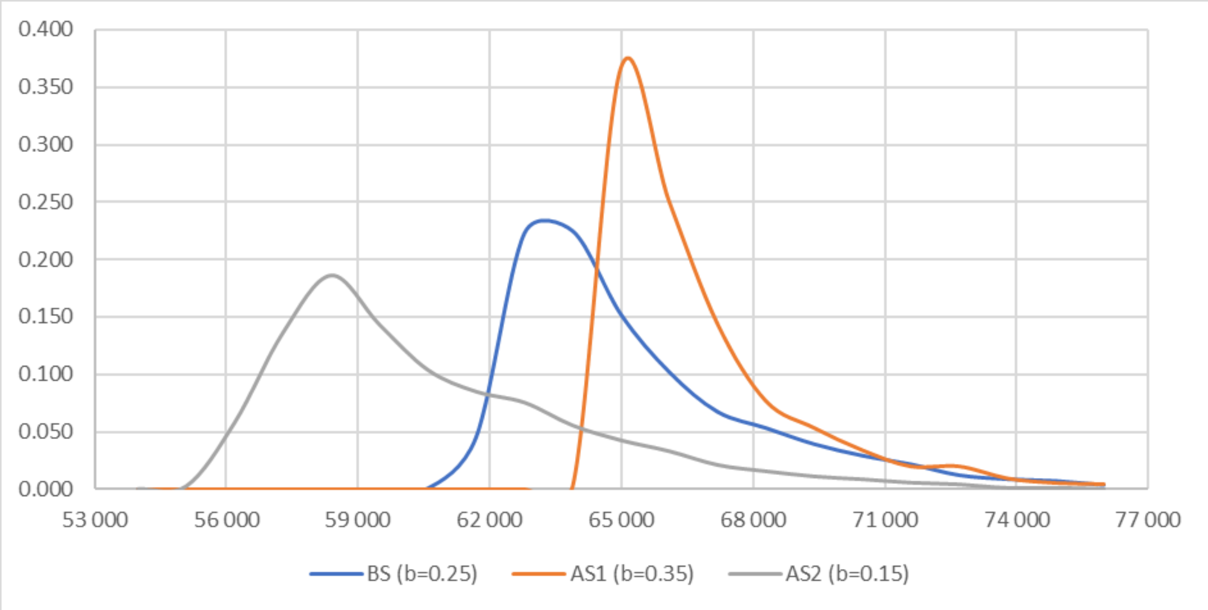
5. Results and discussion

Based on estimated parameters and equation (5) we estimated probability distribution of the entity value for the basic scenario *BS* (with the parameter *b* ($ROIC_B$), $b = 0.25$) and two alternative scenarios *AS* (*AS1* for $b = 0.35$, *AS2* for $b = 0.15$). Results are graphically presented in Figure 4 and basic statistical description is depicted in Table 3.

Table 3: Results for given scenarios

	b	*E(V)*	*σ*	*pct (0.1)*	*pct (0.9)*
BS	0.25	64 900	3 000	62 100	69 200
AS1	0.35	66 500	2 400	65 000	69 600
AS2	0.15	60 100	3 400	65 600	70 600

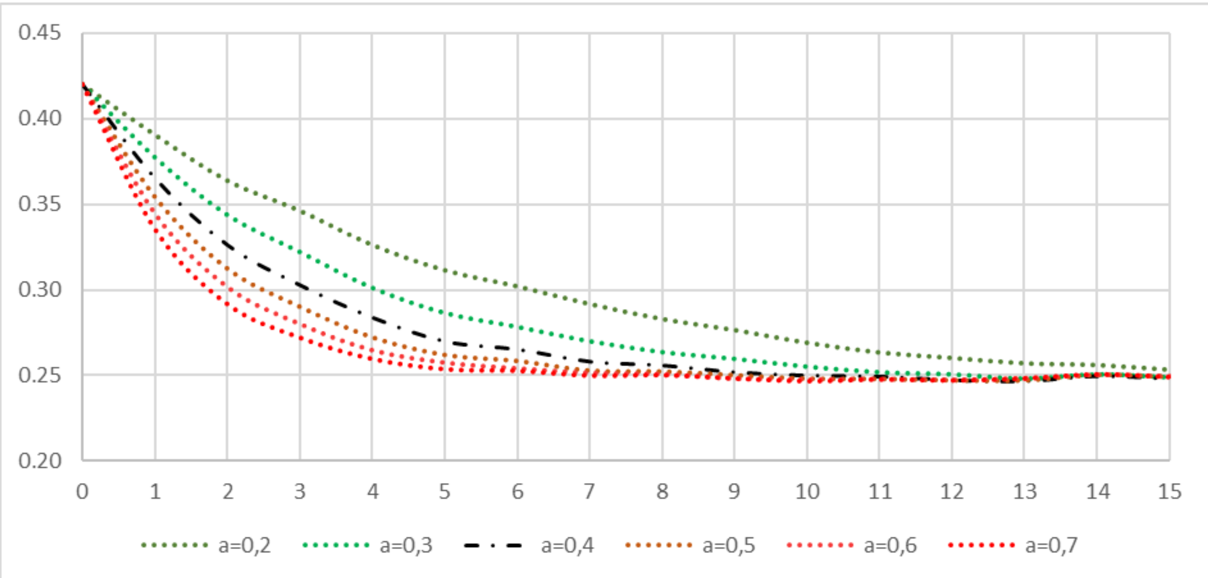
Figure 4: Estimated probability distribution of the entity value for given scenarios



It is clear from the Table 3 and Figure 4, that with the growing difference between the initial value of *ROIC* and the long-term sustainable value of *ROIC*, not only does the expected value of the company decrease, but there is also a substantial increase in the standard deviation. It would also be interesting to compare these results with a model that only considers the jump change in *ROIC*.

Subsequently, a sensitivity analysis of the influence of the approach velocity, parameter *a*, on the expected value and the probability distribution of the value was performed. Parameter *b* was fixed on $b = 0.25$. Evolution of the $E\left(ROIC\left(t\right)\right)$ for different *a* is captured in Figure 5.

Figure 5: Evolution of the $E\left(ROIC\left(t\right)\right)$ *for different parameter a*



The effect on the resulting value can then be observed in Table 4 and Figure 6.

Table 4: Sensitivity analysis

a	*E(V)*	*σ*	*pct (0.1)*	*pct (0.9)*
0.2	66 500	4 300	62 121	73 428
0.3	65 500	3 600	62 090	70 933
0.4	64 900	3 000	62 063	69 173
0.5	64 400	2 600	62 047	67 879
0.6	64 200	2 300	62 061	67 182
0.7	63 900	2 100	62 088	66 664

From the results in Table 4, we can observe that the velocity of approaching the long-term sustainable level of *ROIC* does not have a significant effect on the expected value. However, as the approach velocity increases, the standard deviation decreases.

6. Conclusion

In the paper, an influence of the return on invested capital convergence process on a company's value within two stages discounted cash flow model was investigated. We focused on the violation of the simplified and unrealistic assumption of sharp drop (rise) of the return on invested capital between first and second stages, which is often used in the basic two-stage valuation model. Under the assumption that the current level of the ROIC is different from its sustainable level, we investigated influence of the stochastic mean-reversion Vasicek process on a company's value. For simplification, ROIC convergence was the only parameter, which determined the length of first stage in this paper. We found out that the growing difference between the initial value of ROIC and the long-term sustainable value of ROIC, not only does the expected value of the company decrease, but there is also a substantial increase in the standard deviation. We also concluded that the velocity of approaching the long-term sustainable level of ROIC does not have a significant effect on the expected value.

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Supplementary Pension System in the Czech Republic

Kateřina Kořená[1], Josef Novotný[2]

Abstract

This paper focuses on the Czech pension system. The author aims to discuss the problem connected with a performance of the main different types of pension funds in supplementary pension system in the Czech Republic. The main aim of this paper is to point to the significant risk of investing for longer period in transformed funds and conservative funds which yield is too low. The final part is a conclusion in which possible solutions are proposed.

Key words

Pension funds, pension reform, pillars of pension system, supplementary pension system retirement security.

JEL Classification: G29, H55

1. Introduction

This paper focuses on the Czech pension system. The author aims to discuss the problem connected with a performance of the main different types of pension funds in supplementary pension system in the Czech Republic. Overall, the first part deals with the short description of the pension system in the Czech Republic and the second part focuses on investing in these mentioned above pension funds. The main aim of this paper is to point to the significant risk of investing for longer period in transformed funds and conservative funds which yield is low. The final part is a conclusion in which possible approaches and solutions are proposed. Standard methods of scientific work are used in the paper. In the first part, the description method is mainly used, specifically to present the current state of the pension system in the Czech Republic. Then, the methods of comparative analysis and synthesis are used for the clarification of the problem to be solved.

2. Czech Pension System

Up to the present, the Czech pension system is defined as a two-pillar system. The first and by far the thickest pillar is the state pension system, which is paid into by all employed citizens. People pay 28% of their gross salary into their pensions.[3] This mandatory pillar system is termed pay as you go and the scheme is administered by the Czech Social Security Administration. The system was introduced in its current form by the Pension Insurance Act, which came into force in 1996.[4] It works as a defined benefit scheme. The required insurance

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[3] Employers pay 21.5% of the payroll and employees 6.5% of their earnings. The self-employed pay the 28% of their earnings themselves.
[4] Act No. 155/1995 Coll., on pension insurance.

period has been 35 years since 2019.[5] The retirement age for all persons born after 1971 is 65 years in all categories.[6] This pension is paid monthly and is made up of two components: a basic amount and a percentage amount. The basic amount is a fixed sum for all pensions. In 2019, it was 3270 CZK per month; from 2020, it will be 3490 CZK per month. The percentage amount is defined individually based on the number of insured years and the applicant's average earnings from the age of 18 until the year before retirement.

On the contrary, the third pillar – supplementary pension system - is voluntary and is based on investing in pension funds. This voluntary supplementary pension scheme is run by pension companies on a defined contribution basis and commenced in 1994. The system initially only consisted of the supplementary pension insurance scheme. The 2011 "small" reform closed all the pension funds as of 30 November 2012 and automatically transferred the savings of the participants to "transformed funds". Transformed funds still offer an annual non-negative return guarantee, the ability to receive an old-age pension from the age of 50, and the possibility to terminate the contract and receive payments. Since 1 January 2013, new participants in the supplementary pension system can only join the supplementary pension savings scheme.

2.1 Reform in 2013 and Supplementary Pension System

Officially, the pension reform started on 1 January 2013. There were important changes to the existing third pillar (Vostatek, 2012). This reform newly registered two types of funds in this supplementary pension system: the old transformed funds and the new participating funds. The most important point is that, from 1 January 2013, it is possible to enter only the new registered type of pension fund. Participants in the supplementary pension insurance scheme may switch to the supplementary pension savings system at any time and select the participating fund of their choice and a particular investment strategy. Another important change in this pension scheme was the change to the state contribution. Until this change, it was possible to receive the state contribution even when saving only 100 CZK monthly; now, it is necessary to save at least 300 CZK monthly. The change in the contribution is described in Table 1.

Table 1 State Contribution before and after the Pension Reform in 2013

Monthly Payment (CZK)	State Contribution before January 1 2013 (CZK)	State Contribution after January 1 2013 (CZK)
100	50	0
200	90	0
300	120	90
400	140	110
500	150	130
600	150	150
700	150	170
800	150	190
900	150	210
1000	150	230

Source: *The Association of Pension Companies of the Czech Republic*

5 From 2010, the time of study is not included in this obligatory time.

6 The statutory retirement age will reach 65 years in 2030 based on current legislation and every fifth year it will be discussed by government and can be changed.

3. Supplementary Pension System

Now, we focus on the financial instruments that are designated for retirement in the third pillar. According to the latest legislation, in the Czech Republic at present there are two types funds in this schema – transformed funds and participating funds. Entrance to the transformed funds is not possible.[7] Participating funds are now the only possibility for investing in the pension funds. The main differences between transformed and participating funds are the following:

- Transformed funds are funds with a non-negative return guarantee;
- People can withdraw half of their invested money from transformed funds after 15 years;
- In participating funds, people can choose a more dynamic investment strategy;
- The yield from participating funds depends on this strategy, and it is not guaranteed.

In the transformed funds, most of the invested money is still allocated – see Table 2 – although the value of the assets in the participating funds is quickly increasing from less than of 0.5% from the total invested assets in 2013 to 14% in 2019 and to almost 18% in 2021. The total invested assets have grown by almost 100% in this period.

On the other hand, the increase in the number of participants in the participating funds does not balance the decrease in the transformed funds. The total number of participants was 10.7% smaller in 2021 than in 2013. The possibility to change the fund was apparently chosen by low number of participants in originally transformed funds. Probably the main motivations to remain are the non-negative return guarantee and the possibility to withdraw funds without losing the state contribution from the age of 50 for those who joined before 1999.

Table 2: Total Invested Assets (in million CZK) and Number of the Participants in the Third Pillar

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total Assets/Transformed Funds	280 688	312 102	339 311	364 985	383945	404 350	427 017	449 373	465 788
Total Assets/Participating Funds	1265	4 840	10 133	18 048	29 943	42 715	60 098	78 512	100 921
Participants/Transformed Funds	4 870 174	4 557 812	4 256 679	3 976 341	3 688 675	3 470 026	3 301 995	3 134 354	2 962 412
Participants/Participating Funds	91 027	228 812	367 728	542 491	763 332	966 982	1 139 434	1 281 406	1 467 649

Source: The Association of Pension Companies of the Czech Republic

3.1 Performance of Funds

If we look at the performance of the pension funds during recent years, it is clear that there is a big problem especially in case of transformed fund and funds with conservative strategy. These funds are not able to overcome inflation because they naturally focus on bonds with low credit and exchange rate risk. In Table 3 is demonstrated low yield of transformed funds in connection with increasing inflation.

[7] From 1 January 2013.

Table 3: Performance of Transformed Funds and Inflation from 2013 until 2021 (in %)

Year	2013	2014	2015	2016	2017	2018	2019	2021	2022
Inflation (%)	1,4	0,4	0,3	0,7	2,5	2,1	2,8	3,2	3,8
Pension company									
Allianz	1,60	1,64	1,38	1,03	0,41	0,68	0,94	0,66	0,89
AXA/Uniqa	2,29	1,46	1,10	1,03	0,76	0,92	1,26	0,89	0,51
Conseq	2,17	0,70	0,40	0,47	0,16	0,58	1,50	0,38	0,69
Česká spořitelna	1,30	1,42	0,85	0,68	0,51	0,51	1,69	1,00	0,98
ČSOB	1,70	1,40	1,20	0,70	0,63	0,76	1,0	0,70	0,40
ING/NN	1,41	1,13	0,88	0,66	0,69	0,61	0,95	0,71	0,33
Komerční banka	1,44	1,35	1,16	0,66	0,49	0,51	0,60	0,36	0,43
Česká pojišťovna /Generali	2,10	1,70	1,40	0,94	0,84	1,10	1,75	1,31	0,24

Source: The Association of Pension Companies of the Czech Republic, Czech Statistical Office

In Table 4 you can see offered risk profiles of participating funds, for the purpose of simplification there have been chosen two types of funds – obligatory conservative fund and at that time the most dynamic strategy fund of the selected pension company.

Table 4: Performance of Participation Funds and Inflation from 2013 until 2021 (2 Types of Funds = Obligatory Conservative and the Most Dynamic Strategy of the Pension Company, in %)

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Inflation	1,4	0,4	0,3	0,7	2,5	2,1	2,8	3,2	3,8
Pension Company/Fund									
Allianz									
Conservative fund	1,44	1,31	1,22	-0,04	-1,63	0,30	2,24	1,20	-1,70
Dynamic fund	1,76	2,78	4,98	1,51	4,07	-6,86	15,77	7,56	10,68
AXA/Uniqa									
Conservative fund	0,49	2,67	0,59	0,02	-1,38	-0,84	1,20	0,64	-2,58
Stock fund	xxx	xxx	xxx	xxx	xxx	xxx	xxx	14,41	24,46
Conseq									
Conservative fund	0.69	1,39	0,51	0,09	-0,90	-0,98	1,47	0,42	0,25
Global stock fund	19,53	12,71	-0,08	10,81	9,96	-9,69	18,96	-3,92	23,40
Česká spořitelna									
Conservative fund	0,44	1,34	0,50	-0,05	-0,62	0,19	2,59	1,02	-4,16
Dynamic fund	0,17	7,02	-1,04	7,42	8,2	-6,08	18,75	6.14	12,99
ČSOB									
Conservative fund	0,94	2,68	1,35	0,00	-0,94	-0,83	2,15	1,54	-4,23
Dynamic fund	0,66	3,28	7,66	5,36	5,53	-10,09	25,31	6,51	22,40
ING/NN									
Conservative fund	0,27	0,61	1,15	0,21	-1,93	-0,07	1,26	1,36	-3,76
Growth fund	xxx	xxx	-11,53	9,35	14,04	-9,22	17,58	-2,20	21,65

Komerční banka									
Conservative fund	0,36	1,33	0,36	-0,15	-1,57	-0,83	1,49	0,77	-2,57
Dynamic fund	2,16	5,81	1,60	0,87	7,51	-9,51	16,42	3,42	12,91
Česká pojišťovna/Generali									
Conservative fund	2,46	0,87	0,97	-0,14	-0,30	-0,34	1,44	0,53	-3,44
Dynamic fund	3,53	1,84	-0,32	6,36	8,20	-9,13	17,91	5,38	13,07

Source: The Association of Pension Companies of the Czech Republic, Czech Statistical Office

Particularly in case of longer-term investing, transformed and conservative pension funds cannot be a suitable form of an investment - primarily in case that they will be the only investment for your retirement. The value of this money can be lower in comparison with the value of this previous invested money because of inflation. Concerning the dynamic funds, the performance is higher in comparison to the transformed and conservative funds. This result is connected with the portfolio of these funds because transformed and conservative funds have not in their portfolios with one exception stocks (transformed fund Uniqa 0, 01% of stock instruments in total portfolio).

In case of conservative funds this portfolio without stocks can be logical because they can be intended for very conservative investors or for investing for a short period. But in case of transformed funds this portfolio is set in this way because of the above mentioned non-negative return guarantee. Especially for this reason these funds have portfolios created from non-risky financial instruments. It is necessary to realize that more than 80% of total assets is still in transformed funds – see Table 2. And there are participants in transformed funds with relatively long investment horizon (about 10 years or more). For them investing there is not reasonable because of this low yield primarily in comparison with inflation.

3.2 Risk-adjusted performance ratio of pension funds

In following tables, the risk-adjusted performance ratio[8] is calculated as a ratio of real performance (return) and volatility (risk). Return and volatility of transformed pension funds are calculated as the average return and volatility of all these funds in the Czech market from 1995 and 2013[9] to 2021 on annual basis[10]. It is clear that these funds were not able to overcome inflation during these periods – see Table 5.

Table 5: Real Performance (IRR above Inflation), Risk (Volatility), and Risk-Adjusted Performance Ratio of Transformed Pension Funds from 1995 to 2021 and from 1995 to 2021

Transformed Funds	1995 – 2021	2013 – 2021
Real Performance	-0,02 % p.a.	-1,29 % p.a.
Volatility	2,1 %	2,0 %
Risk Adjusted Performance Ratio	-0,008	-0,63

Source: The Association of Pension Companies of the Czech Republic, Czech Statistical Office, author

The return and volatility of the participating funds are calculated from 2013 to 2021. Both are calculated as moving average on month interannual basis. For this calculation participating funds of Conseq Pension Company have been selected as important representatives of these funds – see Tables 6, 7, 8.

[8] Real performance is expressed as the performance minus inflation rate (IRR above inflation).
[9] For comparison with participating funds.
[10] Because of announced data.

Table 6: Real Performance (IRR above Inflation), Risk (Volatility), and Risk-Adjusted Performance Ratio of Conseq Global Stock Fund from 2013 to 2021

Conseq Global Stock Fund	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years
Real Performance	7,745%	5,791%	4,997%	5,055%	4,992%	5,078%	4,789%	6,637%
Volatility	15,16%	6,30%	4,12%	3,27%	3,13%	2,35%	1,55%	1,66%
Risk Adjusted Performance Ratio	0,51	0,92	1,21	1,54	1,59	2,16	3,09	4,00

Source: The Association of Pension Companies of the Czech Republic, Czech Statistical Office, author

Table 7: Real Performance (IRR above Inflation), Risk (Volatility), and Risk-Adjusted Performance Ratio of Conseq Bond Fund from 2013 to 2021

Conseq Bond Fund	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years
Real Performance	0,873%	0,950%	0,837%	0,679%	0,650%	0,775%	0,858%	0,949%
Volatility	3,59%	1,91%	1,29%	0,85%	0,67%	0,74%	0,83%	0,85%
Risk Adjusted Performance Ratio	0,24	0,50	0,65	0,80	0,97	1,05	1,03	1,12

Source: The Association of Pension Companies of the Czech Republic, Czech Statistical Office, author

Table 8: Real Performance (IRR above Inflation), Risk (Volatility), and Risk-Adjusted Performance Ratio of Conseq Obligatory Fund from 2013 to 2021

Conseq Obligatory Conservative Fund	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years
Real Performance	-1,0%	-0,70%	-0,71%	-0,76%	-0,76%	-0,71%	-0,71%	-1,0%
Volatility	3,12%	1,69%	1,04%	0,79%	0,69%	0,80%	0,81%	0,70%
Risk Adjusted Performance Ratio	-0,32	-0,42	-0,68	-0,96	-1,10	-0,89	-0,87	-1,41

Source: The Association of Pension Companies of the Czech Republic, Czech Statistical Office, author

According to these tables, conservative fund was not able to overcome inflation. The return is similar and the volatility is slightly going down. On the other hand, both bond and global stock funds were able to overcome inflation. Returns of bond fund and global stock fund vary not much in this period. Volatility of bond fund is slightly decreasing but volatility of global stock fund is decreasing a lot. If we focus on the risk adjusted performance ratio of these fund, it is also apparent that there is a difference between them. Concerning the value of risk adjusted ratio of conservative fund, it is changing from -0,32 to -1,41 in this period. In case of bond fund and global stock fund we can important trend – this ratio is going up. This tendency is seen mainly in case of global stock fund. This means that it makes sense to invest for longer time in equity instruments.

4. Conclusion

This final part consists of a conclusion that summarizes the knowledge gained. The pension system is itself a long-run scheme, however, it is possible to state that there has been no bigger progress in solving this retirement problem. The future of the pension reform in the Czech Republic is uncertain. The situation is unclear. It seems improbable that the necessary new pension reform can be approved quickly because of contemporary situation (Covid 19, war in Ukraine, potential coming economic crisis). Therefore, it is important to use at least this supplementary pension system (the third pillar) as good as possible. Because the performance of the transformed pension funds in particular is low, it would be a good idea to encourage participants to switch to funds without a capital guarantee. In the case of the participating funds, it is very important to choose a proper investment strategy according to the time horizon. Investors should choose a strategy according their age. This means that younger people can afford to choose a more dynamic investment strategy. The portfolio of such fund for long-term investment should consist mainly of stocks. If investors choose conservative fund the performance can be even worse than in case of transformed funds. Based on the risk adjusted ratio it is possible to state that equity investments in longer period can bring a higher real return for a unit of risk, too. In conclusion, faster improvement of financial literacy is needed for possible investment in proper pension fund. As Hastings and Mitchell (2011) stated, financial literacy is important for the decision-making process and can also influence retirement wealth.

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Assessment of Factors Influencing Final Corporate Income Tax of Wholesale and Retail Sector in the Czech Republic

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Abstract

Taxation is an important way of generating of public revenues. Corporate income tax is one tax of the Czech tax system with stable stream of tax revenues. Its value corresponds with tax liability of individual tax payers. The tax liability depends not only on statutory tax rate but moreover on the determination of tax base or on the values which credited it. The pyramidal decomposition of the total tax liability on individual indicators is used in the case of wholesale and retail sector during period between years 2010 and 2020. Functional method is applied for the assessment of influence of indicators if multiplicative relationship among indicators is determined. Adjusted tax base I was identified as the indicator with the highest impact and the indicator tax loss with the lowest impact on the changes of the final tax liability.

Key words

Corporate income tax, total tax liability, pyramidal decomposition, functional method, wholesale and retail sector

JEL Classification: H20, K34, H25

1. Introduction

Taxes are considered as one kind of incomes of public budgets. Public incomes can be divided into taxes, charges and borrowings. Tax as a general rule can be defined as mandatory, irreversible, regular, non-equivalent payment to public budget without certain target. The role of taxes in economy is clear from main functions of public sector. Ability to allocate sources in the case of market failures, redistribution of wealth in society, mitigating cyclical fluctuations in the economy and obtaining funds for public budgets are the most important tasks of tax policy. Impacts of setting of tax policy is clear from tax systems of individual countries. In response to it direct and indirect taxes as the most basic tax classification are an integral part of them. Income taxes and property taxes as direct taxes are paid by the taxpayer at the expense of its own income and it is assumed that it cannot transfer them to another entity. In the case of indirect taxes, it is assumed that the entity that pays tax does not pay it from its own income, but that it transfers tax to another entity. The tax is passed on through a price increase. (Kubátová et al., 2004)

When it comes to role of income taxation, income taxes can be assessed as the one of the pillars of modern tax systems. They should be perceived as just, bearable, simple and legally perfect. Nevertheless, it is hard to get them to be seen as fair. It means that it is important to emphasize the role of benefit principle in the case of income tax. Ability to provide certain level of public services can support willingness to pay income taxes and to assess them as fair

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value for consumption of public goods. The following also appear to be problematic: complexity of determining of the tax liability that increases imputed costs of taxation, unfairness in tax burden distribution, high marginal tax rates or impacts of European tax integration process. (Kubátová, 2018)

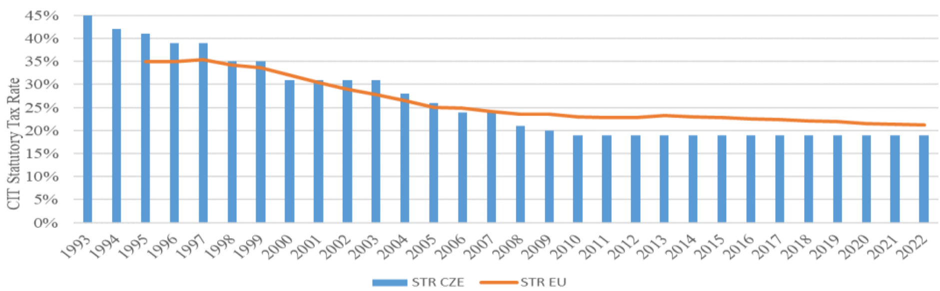
Corporate income tax is one of the youngest taxes. During its existence, it had to face the problem of determining the taxable income. The tax subject (corporate) must be able to identify the value of corporate income. It is derived from the difference between incomes and costs and as such it is not possible to calculate it without respecting accounting principles. In spite of it, the short history of this tax has undergone several important changes from specific surcharges for financial institutions, extraordinary taxation of war profits to decreasing of nominal tax rates and significant extension of tax base. (Kubátová, Vítek, 1997) The corporate income tax is accompanied by its own problems as difficulties in determining and manipulating of corporate tax base or double taxation of dividends. (Lisztwanová, Ratmanová, 2021). Identification of problems of corporate taxation implies question if this tax should exist at all. The following suggestions emerged: replace this tax only with individual income tax, replace it only by value added tax or setting cash flow as a tax base. (Kubátová, 2018)

Nevertheless, the positive aspects of corporate tax can be identified such as limited liability of legal entities, way to pay for consumption of public goods, taxation of otherwise uncapturable incomes or taxation of economic rent as a difference between corporate`s earnings and return on investment required by shareholders. (Kubátová et al., 2004)

In spite of the above-mentioned facts, the corporate income tax is integral part of tax system of almost countries from the all over the world and it has impact on decisions of individual corporates as all other taxes. The individual aspects in determining corporates` tax liability offer to use allowances, credits or deductions, whereas an effort to support or to eliminate certain activities is observed. (Lisztwanová, Ratmanová, 2021)

The role of corporate income tax in the case of the Czech tax system is clear from figure 2. This chart provides data about development of tax revenues coming from corporate income tax during observed period 2010 - 2020. This time period is connected with the specific tax change. As it is clear from figure 1, the year 2009 was the last year when 20% statutory tax rate (STR) was used, while the tax rate fell by more than 26 % between 1993 and 2010.

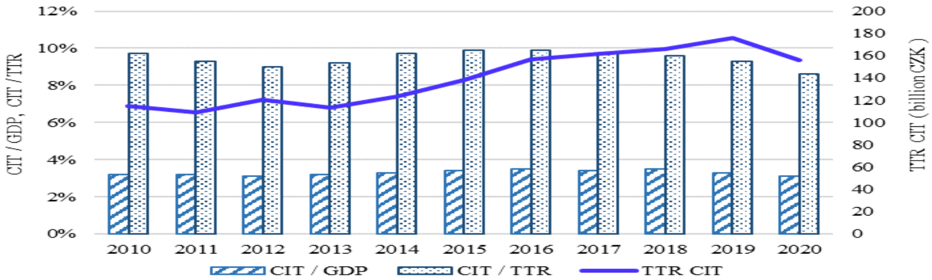
Figure 1: Development of corporate income statutory tax rate 1993 - 2022



Source: Authors` processing according to data of the European Commission and The Act no. 586/1992 Coll., on Income Taxes

Despite this fact the total tax revenues (TTR) generally increased in observed period except in the year 2020. The total tax revenues even reached the value 175 649 mil. CZK in the year 2019 which was the highest value of it all. Therefore, it can be confirmed that decreasing of the tax rate must not always cause decreasing of the total tax revenues. The development of ratio between CIT tax revenues and total tax revenues is clear from the figure 2 as well. Simply said stable development without fatal drops if the last observed year 2020 as the year influenced by COVID 19 pandemic is excluded from observation. The following indicator which is clear from figure 2 is tax quota. Tax quota declares relationship between corporate income tax (CIT) tax revenues and GDP. This indicator is influenced not only by tax conditions but moreover by certain phase of economic cycle. Development of it copies the ratio between the corporate income tax revenues and the total tax revenues. Respecting details of it, this information should not be viewed as something that should be assessed negatively. It can be explained as the impact of higher GDP growth rate than the corporate income tax revenues growth rate.

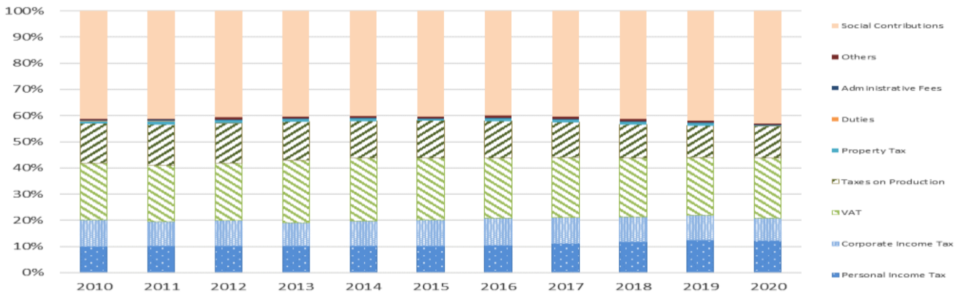
Figure 2: The role of corporate income tax in the case of the Czech tax system



Source: Authors` processing according to data of the European Commission and of Finanční správa

As it has been already mentioned, corporate income tax is able to generate revenues to public budgets. Its role in the case of the Czech Republic is clear from figure 3, which describes the structure of the individual kinds of public revenues during the observed period.

Figure 3: Tax mix of the Czech Republic



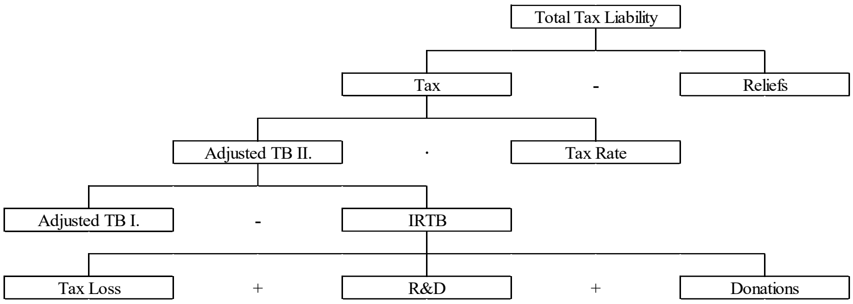
Source: Authors` processing according to data of the Ministry of Finance

The total tax revenues can be described as a stable revenue, which value depends on the total tax liability of individual tax subjects. The corporate income tax liability can be influenced by many factors. The assessment of the impacts of them on the total tax liability has been already made by Lisztwanová, Ratmanová (2017) respecting data of the all sectors and by Lisztwanová, Ratmanová (2018) in the case of finance and insurance sector, by Lisztwanová, Ratmanová (2020) for manufacturing sector and by Lisztwanová, Ratmanová (2021) for construction sector. The goal of the paper is to assess impact of the main facts influencing the final value of the tax liability, such as the tax-deductible costs, changes of tax rate, items reducing tax base and tax reliefs in the case of wholesale and retail sector. The pyramidal decomposition of the total tax liability and analysis of variances is used for assessing influence of individual items on the total tax liability during period 2010 – 2020 using public data of Finanční správa.

2. Methodology

Detailed impacts of tax policy decisions are clear from calculation of tax liability. Exact determination of it is stated within The Act. 586/1992 Coll., on Income Taxes and is affected by tax rates, tax base, tax deductions and tax reliefs. These indicators can be described as main indicators influencing the total tax liability and for that reason the total tax liability can be decomposed on these individual indicators. Decomposition of the tax liability as the top indicator on influencing sub-indicators is way for assessment of their impact. It means that every change of sub-indicator can be used for explaining of changes of the total tax liability as a top indicator. Details of this decomposition are clear from figure 4.

Figure 4: Pyramidal decomposition of total tax liability



Source: Authors` processing according The Act no. 586/1992 Coll., on Income Taxes

According to Dluhošová (2004), Zalai et al. (2007), Dluhošová et al. (2021), Zmeškal et al. (2013) changes of a top indicator, which can be splitted into its individual items, can be assessed by changes of individual indicators. (Lisztwanová, Ratmanová, 2017) It can be stated that the change of the top indicator is explained through the changes of the individual indicators:

$$\Delta y_x = \sum_i \Delta x_{a_i}, \tag{1}$$

where x is the analysed indicator, Δy_x is increment in the influence of the analysed indicator, a_i is the indicator by which Δy_x can by partially explained, Δx_{a_i} is the influence of the indicator a_i on analysed indicator x. If additive relationship between indicators exists it can be expressed by following formula:

$$\Delta x_{a_i} = \frac{\Delta a_i}{\sum_i \Delta a_i} \cdot \Delta y_x, \tag{2}$$

where $\Delta a_i = a_{i,1} - a_{i,0}$, $a_{i,0}$, and $a_{i,1}$ is the value of the indicator i respecting starting (0) and ending (1) state.

As it is clear, not only additive relationship between indicators exist but moreover multiplicative relationships are identified. In the case of identified multiplicative relationship, there are different methods for calculating the influence of the individual indicator on the top indicator. The one of them which can be used is functional methods, that expresses the combined simultaneous impact of the all indicators explaining of their influence on the top indicator.

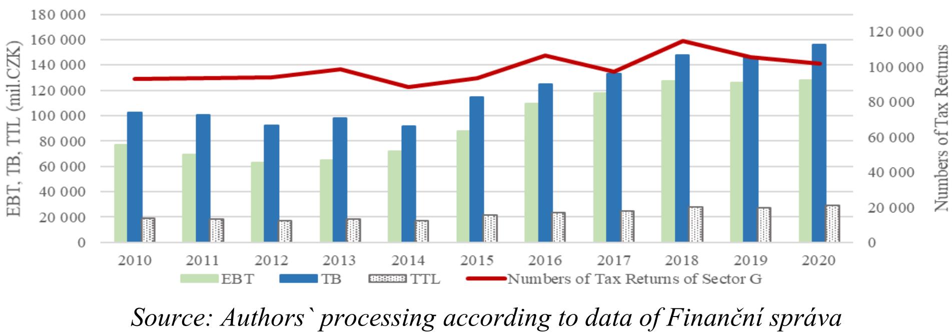
At first glance, the construction of the tax base for corporate income tax is simpler than for personal taxes. However, a more detailed analysis shows that the structure and definition of tax costs is very often more complicated than in the case of personal income tax. However, the advantage is that there are not so many specific tax reliefs built into the corporate tax structure comparing it with the individual income tax. Taxation of companies is also not complicated by the separation of the total tax base between partial tax bases. Designation of tax base reflects decisions and changes of tax policy. When it comes to corporate income taxation, the tax base is influenced by respecting for example way of depreciation of fixed assets, by inventory valuation method or determination of tax-deductible cost (Musgrave and Musgrave, 1994), (Kubátová, 2018). As input data to settle tax base it is necessary to take into account the value of accounting profit or loss, incomes or amounts, which are tax-exempted or which may reduce accounting profit, if they are included into accounting profit, expenses not recognized as expenses or other amounts which increased the accounting profit, if they are included into the accounting profit. (Lisztwanová, Ratmanová, 2019) Adjusted tax base I. reflects accounting results affected with all these kinds of adjustments. On the other hand, adjusted tax base II. is affected with items reducing tax base such as tax loss, research and development expenses and donations activity.

The tax loss carries forward or backward is a provision that allows a taxpayer to move a tax loss to future or to previous years to decline tax base and finally to reduce tax liability. The period that may apply this type of the deduction is five years in the case of forward shifting and two years in the case of backward shifting. The research and development expenses (R&D) were used for the first time in the year 2005 as deduction from tax base. Specific impact of it is that research expenses decrease the taxable earnings twice. Firstly, as expenses as a part of accounting profit and secondly as the item reducing tax base. The aim of third reduction of the tax base is via the value of gratuitous transactions (donations) to support financing of education, culture, social, medical, environmental, humanitarian or charitable purposes. (Lisztwanová, Ratmanová, 2019) The total value of the tax liability can be finally decreased by tax reliefs whereas investment incentives and employment of disabled people are considered in this situation.

3. Basic Information about Selected Sector

The power of factors influencing changes in corporate income taxation of the Czech tax system has been already assessed and as well as the same in the case of selected sectors (agriculture, processing industry, construction, finance and insurance sectors). The paper concentrates its attention on wholesale and retail sector (according to the Finanční správa labelled as sector G). The section includes wholesaling and retailing (i.e. buying and selling without further processing) of any kind of goods and providing services related to the sale of goods. Maintenance and repair of motor vehicles and motorcycles are included there as well. (the Czech Statistical Office) Wholesale and retail are the last links in the distribution of goods. Typical wholesalers are those that own the goods they trade, selling under their own name. Wholesalers usually perform operations related to the sale of goods in-house, e.g. physically assemble, sort and classify goods in large quantities, unpack large packages, repackage and redistribute in small quantities, store, refrigerate, deliver and install goods, engage in sales promotion for their customers and mark the goods with a label. Retail is another type of buying and selling of new or used goods mainly to the general public for personal consumption. The most retailers are also the owners of the goods sold, but some act as sales representatives, perform activities for the principal and sell on a consignment or commission basis. (the Ministry of Industry and Trade)

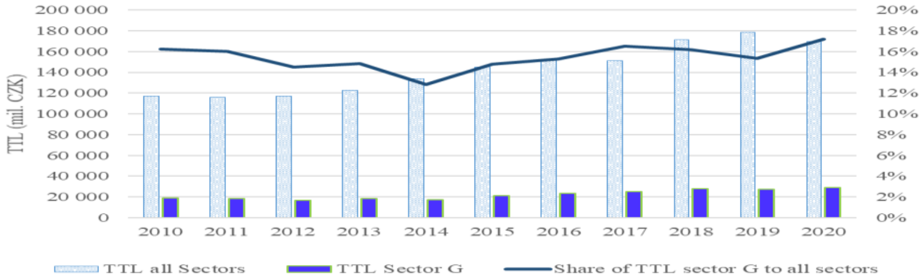
Figure 5: The development of EBT, TB, TTL and numbers of tax returns of sector G during observed periods



Source: Authors` processing according to data of Finanční správa

The basic data about the sector G is clear from figure 5. It can be generally mentioned that the role of sector G growths in the Czech economy even despite the influence of COVID 19 pandemic. Earnings before tax (EBT), tax base (TB) and total tax liability (TTL) constantly increased from the year 2014 to the end of the observed period. Comparison of EBT and tax base is interesting as well. It is clear that the value of the tax base always exceeded the value of EBT. However, the development of number of tax returns implies that there were subjects with troubles and that were forced to stop their activities. These findings are important realizing the fact, that approximately one sixth of the total corporate income tax liability comes from sector G, as it is clear from figure 6.

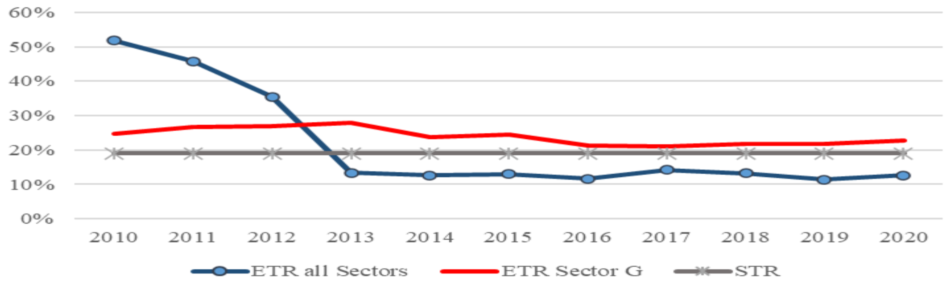
Figure 6: The development of TTL of all sectors and TTL of sector G during observed periods



Source: Authors` processing according to data of Finanční správa

Concentrating on data of figure 7, the sector G is interesting thanks to the value of effective tax rate (ETR). Effective tax rate is the ratio between the final tax liability and earnings before tax and it is influenced not only with statutory tax rates but moreover with all adjustments of the tax base as well as with tax credits. Effective tax rates of sector G are higher than the same ratio in the case of all sectors.

Figure 7: The development of STR, ETR of all sectors and ETR of sector G during observed periods



Source: Authors` processing according to data of Finanční správa

It can be concluded that adjustments of tax base and tax credits do not affect decreasing of tax liability but in the contrary they increase it. So that means that sufficient amount of attention should be given to this sector from a tax point of view.

4. Assessment of Influence of Individual Indicators

As it was mentioned above, the possibility to express the impact of individual indicators on changes of top indicator exists. By this way the indicator with the highest and with the lowest impact can be identified. Finding just these indicators and determining the impact of the rest of the indicators have already been in the centre of observation. Results of these observations discovered differences among individual years of observations and among individual sectors likewise. Nevertheless, it can be generally concluded that respecting the data of all sectors the indicator adjusted tax base I. (ATB I.) was identified as the indicator with the highest impact on the changes of the total tax liability. Reversely, the indicator donations generated the lowest impact. The following findings showed tax loss as indicator with the second highest impact on changes of the total tax liability followed by tax reliefs and R&D expenses. In the case of impact of R&D indicator its increasing role in observed period it was not confirmed. The following fact is interesting as well. In spite of the reality that before observed period the value of statutory tax rate was decreased from 20% level to 19%, impact of it was lower than impact of ATB I., tax loss and reliefs.

If sectors` details must be generally concluded respecting data of the selected period, the results are the similar. Indicator ATB I. as indicator with the highest impact and donations with the lowest impact. The impact of the rest of indicators varied in selected sectors, nevertheless it was confirmed via observations that tax loss was more important than impact of tax reliefs and R&D expenses on the changes of the total tax liability. Partially different development was discovered in the case of Finance and Insurance sector, because R&D expenses were identified as the indicator with the lowest impact and on the other hand donations affected changes of total tax liability more than R&D indicator.

Table 1: Year-to-year changes of selected items within period 2010–2020 in % of the sector G

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TTL	100.0	97.8	91.7	107.0	94.3	125.1	108.5	107.2	111.0	98.7	106.8
STR	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ATB I.	100.0	94.8	92.0	106.3	93.3	124.6	106.9	107.5	108.6	98.4	106.0
Tax Loss	100.0	72.4	85.4	105.6	96.8	125.9	86.7	110.9	75.0	92.7	90.4
R&D	100.0	188.2	96.5	160.2	64.9	111.2	95.8	109.4	82.4	77.2	68.3
Donations	100.0	95.5	110.1	108.2	109.0	97.3	109.2	101.7	119.9	108.1	113.6
Reliefs	100.0	67.9	128.0	70.8	40.1	96.0	119.2	119.4	95.2	98.3	103.5

Source: Authors` calculation according to data of Finanční správa

When it comes to details of sector G, firstly table 1 provides information about development of selected indicators whereas selected period covers years from 2010 to 2020. The table 1 is concentrated on year to year changes and table 2 focuses changes of the observed period if the data of year 2010 are considered as basic data.

Table 2: The changes of selected items within period 2010–2020 in % of the sector G

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TTL	100.0	97.8	89.7	95.9	90.5	113.2	122.8	131.7	146.2	144.3	154.1
STR	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ATB I.	100.0	94.8	87.2	92.7	86.5	107.8	115.3	123.9	134.5	132.4	140.4
Tax Loss	100.0	72.4	61.8	65.3	63.1	79.5	69.0	76.4	57.3	53.1	48.0
R&D	100.0	188.2	181.6	291.0	188.8	209.8	201.0	219.9	181.3	139.8	95.6
Donations	100.0	95.5	105.1	113.8	124.0	120.7	131.8	134.1	160.8	173.8	197.5
Reliefs	100.0	67.9	87.0	61.6	24.7	23.7	28.3	33.8	32.2	31.6	32.7

Source: Authors` calculation according to data of Finanční správa

So as to understand the development of the selected indicators well it is necessary to assess data of table 1 and table 2 together. From data it is clear that the value of statutory tax rate remained unchanged. According to the data about total tax liability (TTL) the years 2011, 2012, 2014, 2019 generated the lower values comparing it with the previous period, nevertheless from data of table 2 is clear that the value of the years 2011, 2012, 2013 and 2014 did not reach level of the basic year 2010. On the other hand, the rest of years importantly exceeded basic data. Changes of ATB I. indicator copied development of the total tax liability and the similar conclusion can be made. The observation of interannual changes of tax loss, it can be stated that its value was mostly lower in present period then in the previous period and never it reached values of the year 2010. The year to the year changes of R&D indicator shows effort to apply this item in reducing the tax base. Comparing it with the data of the basic year 2010 increasing of it is more than obvious. However, data of the years 2018, 2019 and 2020 show decreasing tendency comparing always present year with the previous year. Respecting the data of donations activities, it can be confirmed according to the year to year changes that except years 2011 and 2015 the value of donations was always higher than the value of it in the previous year. Respecting comparison with the data of the year 2010 as basic information, except year 2011 the value of donations was always higher. The reliefs are the last indicator which was observed. From data is clear that its value decreased and never exceeded the value of the year 2010.

The following table 3 provides results of calculations of impact of the changes of the individual indicators identified in figure 4 influencing the changes of the total tax liability as the top indicator.

Table 3: Power of influences of individual indicators of the sector G, absolute changes in mil. CZK

	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20
Reliefs	187.53	-111.47	148.49	215.82	5.85	-26.60	-32.14	9.49	3.16	-6.40
STR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATB I.	-1 136.99	-1 658.20	1 199.61	-1 360.91	4 662.80	1 632.91	1 890.49	2 318.84	-461.96	1 742.51
Tax Loss	597.77	228.93	-74.72	45.78	-353.78	227.94	-162.13	414.29	90.17	110.13
R&D	-65.22	4.82	-80.87	75.61	-15.60	6.52	-13.98	28.62	30.63	32.74
Donations	3.80	-8.12	-7.27	-8.57	2.77	-9.37	-1.91	-22.43	-10.94	-19.90
Δ TTL	-413.12	-1 544.03	1 185.24	-1 032.27	4 302.05	1 831.39	1 680.33	2 748.82	-348.93	1 859.08

Source: Authors` calculation according to data of Finanční správa

The table 3 shows year to year changes expressed in monetary units. As it is obvious from data the changes were positive and negative. It means that year to year the total tax liability grew or declined in observed period. Because of it impact of individual indicators can be described as a positive or negative as well.

Table 4: Power of influences of individual indicators of the sector G, percentage value

	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20
Reliefs	-45.39	7.22	12.53	-20.91	0.14	-1.45	-1.91	0.35	-0.91	-0.34
STR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATB I.	275.22	107.39	101.21	131.84	108.39	89.16	112.51	84.36	132.39	93.73
Tax Loss	-144.70	-14.83	-6.30	-4.44	-8.22	12.45	-9.65	15.07	-25.84	5.92
R&D	15.79	-0.31	-6.82	-7.32	-0.36	0.36	-0.83	1.04	-8.78	1.76
Donations	-0.92	0.53	-0.61	0.83	0.06	-0.51	-0.11	-0.82	3.14	-1.07
Δ TTL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Authors` calculation according to data of Finanční správa

The table 4 shows annual development of the total tax liability expressed as percentages changes, where the annual change of the total tax liability means 100% change. For assessment of impact of the indicators, the following rule is applied. The higher the value of the indicator is, the more this sub-indicator contributed to the development of the total tax liability. With regard the details of the table 3 and table 4, it may happen that the value of the change is zero. According to it, it seems that there is not any impact on the top indicator. Nevertheless, in comparison it with the power of influence of the rest indicators even zero value of influence plays a role. It is lower than the highest positive value and at the same time higher than the lowest negative value of the influence of other sub-indicators. (Lisztwanová, Ratmanová, 2021)

5. Conclusion

With regards the details of the table 4, it can be stated which indicator in the case of the sector G the influenced most the changes of the total tax liability and which one affected it the least. Findings of table 4 are processed in the following table 5 with respect to the above-mentioned rule in determining the final ranking of the effects of individual sub-indicators.

Table 5: Power of influences of individual indicators of the sector G according to the percentage value

	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20
Reliefs	5	2	2	6	2	6	5	4	4	5
STR	3	4	3	3	4	4	2	5	3	4
ATB I.	1	1	1	1	1	1	1	1	1	1
Tax Loss	6	6	5	4	6	2	6	2	6	2
R&D	2	5	6	5	5	3	4	3	5	3
Donations	4	3	4	2	3	5	3	6	2	6

Source: Authors` calculation according to data of Finanční správa

For making detail conclusion following table 6 was made. Its details provide final assessment of the impact of the individual sub-indicators on the top indicator during period between the years 2010 and 2020.

Table 6: Ranking of indicators` impacts of the sector G

	Sector G
Reliefs	4
STR	2
ATB I.	1
Tax Loss	6
R&D	4
Donations	3

Source: Authors` calculation according to data of Finanční správa

It can be confirmed that the indicator ATB I. is assessed as the sub-indicator which the most influenced changes of the total tax liability in the observed periods. Contrary the sub-indicator with the lowest impact was tax loss. It means that sector G is not so much affected by generating tax loss. Interesting is the fact connected with the impact of the statutory tax rate and its role in assessing of order of influence of the individual indicators. As it has been already mentioned statutory tax rate is 19 % since the year 2010. Notwithstanding, used processing of input data and respecting the main rule for assessing of findings caused, that the impact of this indicator was the second highest. It is result of mutual relationships among individual sub-indicators. The impact of the following indicators R&D and reliefs was not as strong as the impact of the indicator – donations. In conclusion it can be confirmed that sector G does not generate differences in the case of the indicator with the highest impact on the changes of the total tax liability. Statutory tax rates and R&D and donations had greater influence than in the case of already evaluated separate sectors and data for all sectors in total. On the contrary the impact of tax loss was the weakest what was not confirmed in the case of all sectors and selected sectors.

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Impact of Covid-19 and War in Ukraine on the Credit Risk of Debt Assets Portfolio

Josef Novotný[1]

Abstract

The topic of this conference paper is determination of credit risk of a portfolio of 10 debt assets for four time periods (pre-Covid-19 pandemic period, Covid-19 period, post-Covid-19 period and period of war in Ukraine). The main objective of this conference paper is to determine the value of economic capital of debt assets portfolio by using the CreditMetrics model for selected time periods and to compare the calculated value of economic capital for these for analyzed time periods.

Key words

Covid-19, CreditMetrics™, war in Ukraine, economic capital, credit risk, recovery rate, value at risk, asset value model, Monte Carlo simulation

JEL Classification: G21, G24, G28.

1. Introduction

Credit risk represents the potential loss if the counterparty (borrower) is unable to meet its obligations both on time and in full value. Credit risk is the most significant risk in banking industry and failure to manage this risk has led to bank failures many times. Both Covid-19 and the war in Ukraine have had a negative impact on the financial situation of companies and have led to a decline or even recession of the economies. As a result of these negative events, economies are experiencing lockdowns, rising energy prices, supply chain disruptions, etc. The paper focuses on determining the impact of these negative events on the value of credit risk.

The main goal of this conference paper is to calculate the value of economic capital of debt assets portfolio by using the CreditMetrics™ model for selected time periods and to compare the calculated value of economic capital for these for analyzed time periods.

2. Description of the CreditMetrics methodology

The model was developed by J.P. Morgan in 1977 as a mark-to-market model and allows to describe a portfolio of financial assets using VAR methodology. The essence of this methodology is to convert all risks into a common denominator, the change in the value of a portfolio of debt assets (as a result of a change in rating, there is a change in the credit margin that translates into the discount rate that directly affects the present value of the debt asset).

The basis of the model is a transition matrix that gives the probability of moving from one rating category to another.

The VAR represents the maximum possible losses at a given confidence level (usually 99% but more frequently 99.5% or even 99.9%,) over a given time interval and can be interpreted in two different ways.

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1) At a given significance level α, the losses on a portfolio of debt assets ($-\Delta\tilde{\prod}$) over a given time interval will be greater than a predetermined value of loss (*VAR*), e.g. there is only a 1% probability that the loss will be greater than a predetermined value of XZ Euro), this can be expressed by the relation,

$$\Pr\left(-\Delta\tilde{\prod} \geq VAR\right) = \alpha . \quad (1)$$

2) At a given significance level α, the profit on the portfolio of debt assets ($\Delta\tilde{\prod}$) over a given time interval will be less than a predetermined profit level (-VAR), this statement can be written as follows,

$$\Pr\left(\Delta\tilde{\prod} \leq -VAR\right) = \alpha . \quad (2)$$

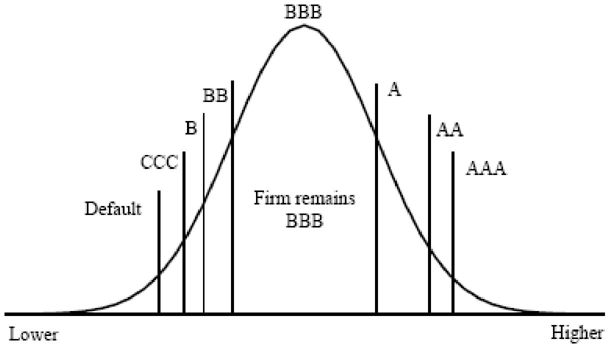
The VAR calculation can be performed using the analytical method or the Monte Carlo simulation method, which is based on a large number of simulations of the evolution of the value of the asset portfolio. The essence of the model is to determine the probability distribution of the asset portfolio value increment (*(* $\Delta\tilde{\prod}$*)* at a given confidence level α. The asset portfolio value increment can be written using the following formula,

$$\Delta\tilde{\prod} = \tilde{V}_P^T - V_P^t = \sum_n \tilde{V}_{n,j,T} \cdot x_n - \sum_n V_{n,i,t} \cdot x_n \quad , \quad (3)$$

where $\tilde{V}_P^T (V_P^t)$ is the initial (predicted) value of the portfolio, $V_{n,i,t}$ is the value and x_n is the quantity of the n-th asset in the i-th rating category in the asset portfolio. $\tilde{V}_{n,j,T}$ represents the value of the n-th asset in the j-th rating category at the end of a predetermined time horizon *T*. The time horizon is generally one year. The value of an asset is based on the rating grade that the asset has at the end of the time horizon.

In the CreditMetrics methodology, the underlying process of developing the value of an asset (debt instrument) $\tilde{V}_{n,j,T}$, is based on the Asset Value Model, which is based on an option-theoretic approach. According to this theory, the value of a firm is a random variable with some distribution. If this asset value should fall so significantly that it is less than the amount of outstanding financial liabilities (the value of the firm falls below the "bankruptcy threshold"), then the firm will be unable to meet its debts to creditors and will default. However, this does not mean that the probability of default must be estimated on the basis of the variability of the value of the firm. Firm value volatility is used to quantify the probability of joint rating changes. In modelling the rating of a firm in a portfolio, the market value of the firm is used as a reflection of market share prices. Then, if the value of the firm exceeds a certain level, the rating will change. This is illustrated in Figure 1.

Figure. 1: Asset value model and thresholds



Source: CreditMetricsTM – Technical document

Assuming that the firm's value thresholds are known, it is necessary to model the change in the firm's value in order to describe the evolution of the rating. The change in firm value is represented by the asset turnover *r*, assumed for modelling purposes to be $r \sim N(0,1)$. Assuming that *r* has a normal distribution, the probability of occurrence of each event can be calculated. The calculation of the thresholds is shown in Table 1 below.

Table 1: Calculation of thresholds for each rating level

Rating	Probability corresponding to the Asset value model
AAA	$1-\Phi(Z_{AA}/\sigma)$
AA	$\Phi(Z_{AA}/\sigma) - \Phi(Z_{A}/\sigma)$
A	$\Phi(Z_{A}/\sigma) - \Phi(Z_{BBB}/\sigma)$
BBB	$\Phi(Z_{BBB}/\sigma) - \Phi(Z_{BB}/\sigma)$
BB	$\Phi(Z_{BB}/\sigma) - \Phi(Z_{B}/\sigma)$
B	$\Phi(Z_{B}/\sigma) - \Phi(Z_{CCC}/\sigma)$
CCC	$\Phi(Z_{CCC}/\sigma) - \Phi(Z_{Def}/\sigma)$
Default	$\Phi(Z_{Def}/\sigma)$

Source: : CreditMetricsTM – Technical document

The asset thresholds (Z_{AA}, Z_A, Z_{BBB},.......Z_D) between each rating category are determined using the normalised normal distribution function Φ (0;1) and the transition matrix.

When simulating the value of the portfolio, correlations between individual borrowers need to be determined. CreditMetrics determines correlations indirectly, based on a set of indices that calculate correlations between borrowers. First, correlation matrices between the industry indices are created using the industry indices of each country and then the borrowers are assigned to each industry (to each index), including their share (w^{odv}) of their activity in the industry. The development of the return on equity of a firm operating in one industry can be written using the following equation,

$$r^A = w^{odv} \cdot r^{odv} + w^{spec} \cdot r^{spec}, \quad (4)$$

where r^A is the stock return of a given firm, w^{odv} is the coefficient of determination and w^{spec} is the proportion of revenue that is firm-specific, r^{odv} represents the portion of returns explained by the sector index, and r^{spec} is a weight characterising the firm's specific return Since standardized returns are assumed (the normalized variance of the firm is σ2 = 1), then we can deduce w^{spec} as follows:

$$w^{spec} = \sqrt{1-\left(w^{odv}\right)^2}. \quad (5)$$

The calculation of correlations between firms can be solved using matrices. The correlation matrix of each index is called the C matrix. Not only do the weights for the individual indices enter into the calculation, but also the specific components, so it is necessary to create an auxiliary matrix $\overline{C}$ *(m+n,m+n)* that includes both, which can be written as follows,

$$\overline{C} = \left[\begin{array}{c|ccc} \multirow{3}{*}{C} & 0 & \dots & 0 \\ & \vdots & \ddots & \vdots \\ & 0 & \cdots & 0 \\ \hline \begin{matrix} 0 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 0 \end{matrix} & & E & \end{array}\right]. \quad (6)$$

The upper left part of the matrix represents the correlations between the individual indices, the lower right (inverse) matrix represents the correlations between the specific components of individual firms that are equal to one (ones on the diagonal) and independent of the specific components of other firms (other values of zero). The rest of the matrix is occupied by zeros, reflecting the absence of correlations between the specific components and the indices. Next, it is necessary to construct a matrix W(m+n,n), where the columns represent individual firms and the rows represent industry weights and firm specific turnovers, this matrix can be written as follows,

$$W = \begin{bmatrix} w_{11} & \cdots & w_{1n} \\ \vdots & \cdots & \vdots \\ \vdots & \cdots & \vdots \\ w_{m1} & \cdots & w_{mn} \\ \hline w_{k1}^{spec} & \cdots & 0 \\ 0 & \cdots & w_{kn}^{spec} \end{bmatrix}. \tag{7}$$

The correlation matrix of individual firms' returns *A(n,n)* is given by the following relation,

$$A = W^T \cdot \overline{C} \cdot W, \tag{8}$$

where W^T represents the transposed matrix *W*.

When simulating the return on assets (credit instruments), it is necessary to take into account correlations between individual borrowers, for this purpose the Cholesky algorithm is used. Firstly, the correlation matrix *A* has to be decomposed into a lower triangular matrix A^* using the Cholesky decomposition, this decomposition is given by the following relations::

$$a_{ii} = \sqrt{\left(s_{ii} - \sum_{k=1}^{i-1} a\right)}, \tag{9}$$

$$a_{ij} = \frac{1}{a_{ii}}\left(s_{ij} - \sum_{k=1}^{i-1} a_{ik} \cdot a_{jk}\right), \tag{10}$$

where *s* symbolizes the elements of the original correlation matrix A, then *a* represents the elements of the lower triangular matrix A^*. The matrix of correlated scenarios *Z* can be written as follows,

$$Z = A^* \cdot Y, \tag{11}$$

where *Y* represents the generated matrix with independent variables with standard normal distribution.

To determine the probability distribution of a portfolio increment, individual assets should be valued at both the initial decision date *t* and the end date of the predetermined time horizon *T*, the value of the asset being based on its rating at that date. The value of an asset at time *T* when assigned to the i-th rating category is given by,

$$\widetilde{V}_T^i = \sum_{T+n}^{T+n} \frac{CF_{T+n}}{\left(1 + {}_t f_{T,T+n}^i\right)^n}, \tag{12}$$

where CF_{T+n} are the cash flows arising from the asset, ${}_t f_{T,T+n}^i$, is the forward rate determined at time *t* for the interval *T,T+n* based on forward yield curves for individual ratings. The forward rate for the i-th rating is given by,

$$f_n^i = \left(1+f_n^F\right)\cdot\left\{\frac{1-RR\cdot\sum_{j=1}^{n}\frac{p_j^i-p_{j-1}^i}{\left(1+f_j^F\right)^j}}{1-p_n^i}\right\}^{1/n}-1, \tag{13}$$

where RR is the expected recovery rate, usually determined from historical data, p_n^i is the probability of default over *n* years in the i-th rating category, f_n^F is the one-year risk-free rate, given by,

$$f_n^F = \frac{\left(1+f_n\right)^n}{\left(1-f_{n-1}\right)^{n-1}}-1+, \tag{14}$$

where f_n is the forward rate (e.g. LIBOR, PRIBOR, EUROLIBOR, IRS – interest rate swap etc).

Using the probability distribution of portfolio gains, economic capital can be defined as the difference between the VAR at a given significance level and the mean of the losses, which can be written as,

$$EK = VaR_\alpha - E\left(-\Delta\tilde{\Pi}\right). \tag{15}$$

3. Credit risk determination using CreditMetrics for Covid-19 period

In this section, economic capital calculations are made. The calculations are made for 4 periods: the pre-Covid-19 pandemic period (calculations are made on data as of January 2, 2020), the Covid-19 period (calculations are made on data as of January 2, 2021), the post-Covid-19 period (calculations are made on data as of January 2, 2022), the period of war in Ukraine (calculations are made on data as of June 1, 2022). The calculations are performed using the CreditMetrics methodology described in the previous section.

3.1 Input data

The calculation of economic capital is performed on a portfolio consisting of 10 bonds traded on the Frankfurt Stock Exchange (FSE) with a nominal value of EUR 10 million, with bonds of each company having a nominal value of EUR 1 million. The important characteristics of the bond portfolio are set out in the following *Table. 2*.

Table 2: Basic characteristics of the bond portfolio

Name	Rating	Maturity	Nominal value	Cupon	pcs.
NIKE	AA-	03/2030	2 000,00 €	2,85%	500
General Electric	BBB+	09/2029	1 000,00 €	4,13%	1000
Daimler AG	BBB+	08/2028	1 000,00 €	1,13%	1000
Tencent	A+	02/2025	200 000,00 €	3,80%	5
BMW	A+	01/2023	1 000,00 €	2,38%	1000
Deutsche Wohnen SE	A-	08/2028	1 000,00 €	1,68%	1000
Deutsche Telekom AG	BBB	07/2023	10 000,00 €	2,25%	100
Oracle Corp.	A	03/2026	2 000,00 €	1,65%	500
Deutsche Bank	BBB+	02/2025	1 000,00 €	2,75%	1000
Sanofi	AA	04/2024	100 000,00 €	0,63%	10

Source: Frankfurt Stock Exchange (FSE)

Table 3 below shows the interest rate swap rates (IRS) required to calculate the risk-free rates. Based on the interest rate swap rates, the risk-free rates are calculated for each period: the pre-Covid-19 pandemic period (2020), the Covid-19 period (2021), the post-Covid-19 period (2022), the period of war in Ukraine (2022*). The following table shows the calculated risk-free rates for the first period (2020) only.

Table 3: Interest rate swap (IRS) and calculated forward rates

Rok	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
IRS_{2020}	-0,20%	-0,18%	-0,12%	-0,01%	0,08%	0,19%	0,30%	0,42%	0,52%	0,63%	0,72%
IRS_{2021}	-0,55%	-0,54%	-0,53%	-0,49%	-0,46%	-0,43%	-0,39%	-0,35%	-0,31%	-0,26%	-0,22%
IRS_{2022}	-0,51%	-0,31%	-0,16%	-0,06%	0,06%	0,10%	0,12%	0,17%	0,23%	0,33%	0,34%
$IRS_{2022*)}$	1,03%	1,75%	1,99%	2,12%	2,20%	2,26%	2,31%	2,36%	2,40%	2,45%	2,46%
fnF_{2020}	-0,20%	-0,17%	0,02%	0,31%	0,43%	0,75%	0,95%	1,27%	1,35%	1,64%	1,60%

Source: Erste Group

Table 4 below shows the recovery rates for each period, for the pre-Covid-19 pandemic period (2020), the Covid-19 period (2021), the post-Covid-19 period (2022) the latest data preceding these periods, i.e. data from the end of the previous year, are always used. As data for the latest (period the period of war in Ukraine (2022*)) are not yet available, long-term averages for European bonds have been used.

Table. 4: Average recovery rates for European senior debt

Year	**Estimated recovery rate**
2019 (4Q)	59 %
2020 (4Q)	55 %
2021 (4Q)	58 %
2022 *	48 %

Source: S&P Global Ratings - Leveraged Finance: European Leveraged Finance And Recovery

The Covid-19 pandemic had an impact on the economies of individual countries, with many lock-downs resulting in large economic downturns, which had negative effects on the financial situation of individual companies, resulting in an increasing probability of default. Similarly, the war in Ukraine has been a negative impact on the financial situation of companies, as there has been a large increase in energy prices, supply chains have been disrupted and there is a risk of energy shortages, which could lead to a large economic recession in Europe. As data are currently not available for the period of the war in Ukraine, data for the period of the 2009 financial crisis were used. Corporate annual default rates are in the following. Table 5.

Table 5: Corporate Annual Default Rates By Rating Category

Year	**AAA**	**AAA**	**AAA**	**BBB**	**BB**	**B**	**CCC/C**
2019 (4Q)	0,00	0,00	0,00	0,11	0,00	1,49	29,76
2020 (4Q)	0,00	0,00	0,00	0,00	0,93	3,52	47,48
2021 (4Q)	0,00	0,00	0,00	0,00	0,00	0,52	10,99
2022 *	0,00	0,00	0,22	0,55	0,75	10,93	49,46

Source: S&P Global Ratings – 2020 - 2022 Annual Global Corporate Default And Rating Transition Study

3.2 Calculating economic capital using CreditMetrics

To derive the covariance and correlation matrix, we first need to calculate the returns. Then, using the forward yield curves that are based on the transition matrix, the bond values for each rating level will be determined. The transition matrix will also be used to derive the transition limits between each rating grade. Subsequently, a Monte Carlo simulation will be carried out to generate 30,000 random returns for each bond. The correlated returns will be determined as the product of these random returns and the Cholesky matrix. Based on the transition limits, each yield will be assigned a rating category and each bond will be assigned its respective value according to this rating. The value of the entire portfolio will be determined as the sum of the values of the individual bonds. In the following Table 6, the resulting portfolio values for each period are shown.

Table 6: Resulting debt portfolio values for Pre-Covid period, Covid period, Post-Covid period and War in Ukraine period in €

	Value at initial rating	Expected value	Expected loss	Value at initial rating	Expected value	Expected loss
	Pre-Covid-19 period (2020)			Covid-19 period (2021)		
NIKE	1 133 704	1 133 520	184	1 266 961	1 266 784	177
General Electric	1 232 849	1 231 781	1 067	1 365 076	1 363 842	1 234
Daimler AG	976 606	975 814	792	1 089 496	1 088 431	1 065
Tencent	1 180 493	1 180 220	272	1 208 803	1 208 544	259
BMW	1 082 154	1 081 941	213	1 087 106	1 086 915	191
Deutsche Wohnen SE	1 027 344	1 026 980	364	1 137 000	1 136 593	407
Deutsche Telekom AG	1 072 600	1 068 798	3 802	1 079 830	1 075 353	4 477
Oracle Corp.	1 045 681	1 045 533	148	1 114 086	1 113 978	108
Deutsche Bank	1 113 781	1 112 923	857	1 151 726	1 149 894	1 832
Sanofi	1 009 731	1 009 647	83	1 040 094	1 040 025	69
Portfolio	**10 874 943**	**10 867 158**	**7 784**	**11 540 178**	**11 530 359**	**9 818**
	Post-Covid-19 period (2022			War in Ukraine period (2022*)		
NIKE	1 188 785	1 187 750	1 035	1 010 869	1 009 769	1 100
General Electric	1 276 928	1 275 362	1 566	1 095 562	1 093 882	1 680
Daimler AG	1 055 109	1 053 558	1 551	900 755	899 100	1 655
Tencent	1 141 635	1 141 324	312	1 048 561	1 048 203	358
BMW	1 049 677	1 049 400	277	998 215	997 886	330
Deutsche Wohnen SE	1 096 074	1 094 924	1 150	938 272	937 041	1 231
Deutsche Telekom AG	1 044 839	1 044 740	99	993 549	993 432	118
Oracle Corp.	1 052 652	1 051 898	755	957 354	956 496	858
Deutsche Bank	1 096 610	1 095 314	1 297	1 005 980	1 004 493	1 487
Sanofi	1 183 404	1 183 259	145	1 108 756	1 108 586	170
Portfolio	**11 185 715**	**11 177 528**	**8 187**	**10 057 872**	**10 048 887**	**8 986**

The results show that in both the Covid-19 and post-Covid periods, there was an increase in the value of the portfolio, which was mainly due to the decline in interest rates (IRS were negative at the beginning of 2021 and 2021). Notably, however, both the Covid-19 period and the Ukraine war period saw an increase in expected losses

Table 7 below shows the portfolio values for the pre-Covid-19 pandemic period (2020), the Covid-19 period (2021), the post-Covid-19 period (2022) and the war in Ukraine period for significance levels 0,1%, 0,5% and 1%, on the basis of which the value of economic capital is then calculated.

Table 7: Portfolio value for different significance levels for two time periods in €

	2020		**2021**	
alpha	**Portfolio value**	**VaR (€)**	**Portfolio value**	**VaR (€)**
0,1	10 210 564	-664 377	10 651 226	-888 951
0,5	10 439 968	-434 974	10 965 653	-574 525
1	10 567 030	-307 912	11 005 840	-534 338
	2022		**2022***	
0,1	10 517 571	-668 144	9 389 728	-793 500
0,5	10 752 471	-433 244	9 535 935	-521 937
1	10 886 700	-299 016	9 586 224	-471 648

Based on the results obtained, the portfolio values were highest for the Covid and post-Covid periods. However, the size of the loss is more important in terms of credit risk. The greatest loss was achieved in the Covid period and in the period of the war in Ukraine.

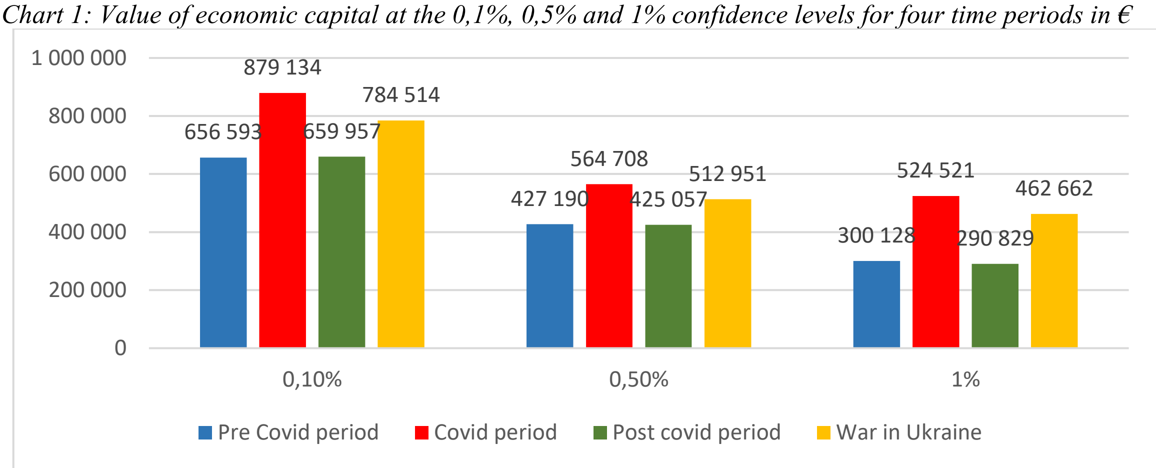
In the period of the war in Ukraine the value of the portfolio will not fall below € 9 389 728 with a probability of 99,9 % (0.01% significance level) and the size of the loss will not exceed € 793 500. In the period of Covid the value of the portfolio will not fall below € 10 651 226 with a probability of 99,9 % (0.01% significance level) and the size of the loss will not exceed € 793 500.

The value of economic capital is calculated as the value of the loss (VaR) at a given significance level less the value of the expected loss. The value of economic capital is shown in Table 8 and Chart 1 below.

Table 8: Value of economics capital for different significance levels and four time periods in €

	Expected loss	Economic capital	Expected loss	Economic capital
VaR v %	2020		2021	
0,1	7 784	656 593	9 818	879 133
0,5		427 190		564 707
1		300 128		524 520
	2022		2022*	
0,1	8 187	659 957	8 986	784 514
0,5		425 057		512 951
1		290 829		462 662

Chart 1: Value of economic capital at the 0,1%, 0,5% and 1% confidence levels for four time periods in €



The results show that there is a slight increase in the value of the debt portfolio for the Covid period (2020). While the value of the portfolio at initial rating increased by € 665 235 i.e. by 6.1%, the expected loss increased by € 2034 i.e. by 26.13%. The value of the economic capital increased by € 222 540 i.e. by 33.89% at the 0.1% significance level.

The results also show that the value of the portfolio for the period of the war in Ukraine (2022*) reached the lowest values (which was mainly due to the rise in interest rates). Meanwhile, the value of the portfolio for the period of the war in Ukraine decreased by 10.08% compared to the post-Covid period, the value of the expected loss increased by € 799 i.e. by 2.4%. The amount of economic capital at the 0.1% significance level increased by € 124,557 i.e. by 18.87% compared to the previous period (post-Covid period).

4. Conclusion

Covid and the war in Ukraine have nagative impacts on firms' financial position, as reflected in increasing probability of default as well as decreasing recovery rate. The results show that

Covid and the war in Ukraine lead to a significant increase in unexpected losses and the amount of economic capital. Given the increasing credit risk, banks will have to make higher provisions to cover expected loss as well as higher economic capital to cover unexpected loss.

Some central banks have also regressed on rising credit risk: Slovakia's central bank increased countercyclical capital buffer rate to 1,5%, also Czech national bank plans to increase countercyclical capital buffer rate from 0,5% to 2,5% over the next 9 months.

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Evaluation of Financial Performance of Insurance Companies by using of TOPSIS

Ingrid Petrová [1]

Abstract

Insurance companies are important part of any economy. Financial performance analysis of company provides fundamental information both to managers, and investors, Evaluation of financial performance seems to be a crucial task of the research. The goal of the paper is to evaluate financial performance based on financial ratio analysis of chosen insurance companies via TOPSIS method. The financial ratios from the liquidity and profitability area have the main influence on financial performance.

Key words

financial performance, insurance company, multi-attribute decision making

JEL Classification: G22

1. Introduction

Insurance industry plays a significant role in economy of any country. It is an important part of the financial system. Insurance business is different to the effect that main amount of the costs cannot be set at the moment when the amount of premium is calculated, i.e. at the moment, when the insurance contract is concluded. Understanding of financial performance of the insurance companies can be consider to be a practical issue from several points of view. Financial performance of insurance company is limited by need of the regulation policy.

Main objective of regulation in general is to protect the policyholder. Further goal of insurance sector regulation is financial stability. Insurance companies, particularly life insurers are significant investor in the financial markets. To ensure financial stability the insurer should focus on profitability, liquidity and solvency area. In general, company needs to know the financial situation and the position within the industry.

Main task of insurance companies is to estimate future losses and ensure that sufficient premium is collected to meet future liabilities following from insurance contracts.

There are many factors that can influence financial performance of insurance company. Many papers relating to financial performance and its determinants in different sector have been published. There exist several methods how to determine significant financial performance´s factors. One of them can be from category Multi Attribute Decision Making (MADM) methods. Financial performance evaluation can be formulated as a typical MADM problem. Many MADM methods have been implemented in several application area.

Türegün, (2022) made comparative empirical analysis on the Multi Criteria Decision Making, which examines the stock performance outcomes with entropy-based TOPSIS (Technique for Order Preferences by Similarity to an Ideal Solution) and VIKOR techniques in tourism companies. Roy and Das (2018) argued that TOPSIS model is also viable in explaining the financial performance of banks.

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The goal of the paper is to evaluate financial performance based on financial ratio analysis of chosen insurance companies for period 2019-2021 via TOPSIS method.

The structure of the paper is following. Next chapter is devoted to the definition of the methods for evaluation. In the third chapter, the data for analysis will be introduced and the evaluation of performance analysis will be made. The last chapter is devoted to main findings and discussion.

2. Theoretical background

Hwang and Yoon (1981) suggested that multiple criteria decision-making MCDM problems can be classified into two main categories: multiple attribute decision making (MADM) and multiple objective decision making (MODM), based on the different purposes and different data types. Within the MADM we work with a limited number of predetermined alternatives and discrete preference ratings.

2.1 TOPSIS

TOPSIS was proposed by Hwang and Yoon (1981) to determine the best alternative based on the concepts of the compromise solution. The compromise solution can be regarded as choosing the solution with the shortest Euclidean distance from the ideal solution and the farthest Euclidean distance from the negative ideal solution. TOPSIS selects the alternative that is the closest to the ideal solution and farthest from negative ideal alternative.

The classical TOPSIS method is based on information on attribute from decision maker, numerical data; the solution is aimed at evaluating, prioritizing and selecting and the only subjective inputs are weights.

Each MADM method can be easily expressed by a decision matrix that includes alternatives and criteria. A decision matrix A is an ($M \times N$) matrix in which element a_{ij} indicates the performance of alternative A_i when it is evaluated in terms of decision criterion C_j, (for $i = 1,2, 3,..., M$, and $j = 1,2,3,..., N$). It is also assumed that the decision maker has determined the weights of relative performance of the decision criteria (denoted as w_j, for $j = 1,2, 3,..., N$).

			Criteria		
Alternatives	C_1	C_2	C_3	…	C_N
	w_1	w_2	w_3	…	w_N
A_1	a_{11}	a_{12}	a_{13}	…	a_{1N}
A_2	a_{21}	a_{22}	a_{23}	…	a_{2N}
A_3	a_{31}	a_{32}	a_{33}	…	a_{3N}
	⋮	⋮	⋮	⋮	⋮
A_M	a_{M1}	a_{M2}	a_{M3}		a_{MN}

Calculation of TOPSIS method can be summarized in the six main steps. Firstly, an element r_{ij} of the normalized decision matrix R can be calculated as follows

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \quad for \ i = 1,2,..,m; j = 1,2,...,n. \qquad 2.1$$

Subsequently, we construct the weighted normalized decision matrix by the help of the formula

$$\mathrm{V_{ij}} = \mathrm{w_j} \cdot \mathrm{r_{ij}} \qquad \mathrm{for} \ \mathrm{i} = 1,2,..,\mathrm{m}; \mathrm{j} = 1,2,...,\mathrm{n}. \qquad 2.2$$

Next step is to determine the positive ideal PIS and the negative ideal solutions NIS. The ideal $A*$ and the negative deal A^{-}solutions are determined from the value of the weighted normalized decision matrix and are defined as follows:

$$A^* = \{(\max v_{ij} | j \in J), (\min v_{ij} | j \in \acute{J}) | i = 1,2,3,.., M\} = \{v_1^*, v_2^*, v_3^*, \dots, v_N^*\}, \quad 2.3$$
$$A^- = \{(\min v_{ij} | j \in J), (\max v_{ij} | j \in \acute{J}) | i = 1,2,3,.., M\} = \{v_1^-, v_2^-, v_3^-, \dots, v_N^-\}, \quad 2.4$$

where $J = \{j = 1,2,3, \dots, N\}$ associated with benefit criteria and $\acute{J} = \{j = 1,2,3, \dots, N\}$ associated with non-benefit criteria.

After that it is necessary to calculate the separation measure. The separation values can be measured using the Euclidean distance. The distance of each alternative from the positive ideal solution is given as

$$d_i^+ = \left(\sum_{j=1}^{n} (v_{ij} - v_j^+)^p\right)^{1/p}, i = 1,2,, \dots, m. \quad 2.5$$

And the distance of each alternative for the negative ideal solution is given as

$$d_i^- = \left(\sum_{j=1}^{n} (v_{ij} - v_j^-)^p\right)^{1/p}, i = 1,2,, \dots, m, \quad 2.6$$

where p ≥ 1.

In the next step we calculate the relative closeness to the positive ideal solution. The relative closeness of the *i-th* alternative A^- with respect to $A*$ is defined as

$$R_i = \frac{d_i^-}{d_i^- + d_i^+}, \quad 2.7$$

where $0 \leq R_i \leq 1, i = 1,2,, \dots, m$.

Finally, we rank the preference order or select the alternative closest to 1. A set of alternatives now can be ranked by the descending order of the value of R_i . Therefore, the best alternative is the one that has the shortest distance to the ideal solution.

2.2 Entropy method

This method uses the assumption that the criterion is not very important if the values of all variants in the criteria matrix according to this criterion are similar; and vice versa, the more the values of individual variants differ, the more important the criterion is. Therefore, this method can be used to determine the weightings of the criteria. Raid (2010) stated that the entropy method is particularly useful for investigating contrasts between sets of data when no preference among criteria can be established. The procedure of this method is following. Firstly, normalization of the arrays of decision matrix to obtain project outcomes p_{ij} is made by using formula

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad 2.8$$

In the next step, we calculated of the entropy values of the project outcomes by the help of the formula

$$E_j = -k \sum_{i=1}^{m} p_{ij} ln p_{ij}, \quad 2.9$$

where $k = 1/\ln(m)$.

And finally, we can define the objective weight based on the entropy method

$$w_j = \frac{1-E_j}{\sum_{j=1}^{n}(1-E_j)}. \quad 2.10$$

2.3 Financial analysis

Financial analysis may be used not only to evaluate the performance of company, but also its line of business. It is an important tool used by manager in the process of decision-making on underwriting activities.

To be able to made financial decision, it is important to made analysis includes the accounting information that describes the company and its industry as well as economic information relating to the company, the industry, and the economy in general.

To understand the financial operations of an insurance companies is important the knowledge of financial statements. The financial performance of any company can show how efficiently management utilizes the resources of the business. Financial ratios are important tools for evaluation financial position of the companies within the industry.

In this study we will examine the financial performance of chosen insurance companies by the help of financial ratios from following financial area, see Table 1.

Table 1: Used financial ratios

Financial area	Formula
Capitalization and leverage	$Operating\ Leverage = \frac{Total\ Insurance\ Liabilites}{Equity\ Capital}$
	$Asset\ Leverage = \frac{Investments}{Net\ Earned\ Premium}$
	$Financial\ Leverage\ Ratio\ (Debt\ Ratio) = \frac{Total\ Assets}{Equity}$
Profitability	$Return\ on\ Assets = \frac{Net\ Income}{Total\ Assets}$
	$Return\ on\ Equity = \frac{Net\ Income}{Equity\ Caital}$
Liquidity	$Cash = \frac{Liquid\ Assets}{Current\ liabilities}$
Solvency	$Solvency\ ratio = \frac{Equity\ Capital}{Net\ Earned\ premium}$

3. Financial performance evaluation

To evaluate financial performance of chosen insurance companies via TOPSIS method, we firstly evaluate the criteria by the help of financial ratio analysis. The weights of these criteria will be calculated by using Entropy method. Based on financial data of five chosen insurance companies we determine by the help of TOPSIS an alternative by their distance from the most appropriate solution. We choose the optimal alternative that has the shortest distance from the ideal solution and the farthest distance from the negative ideal solution.

3.1 Input Data

For analysis we have chosen six insurance companies that are member of Czech Insurance Association. The selection was done according to the order of contractual premiums written in 2021[2]. The first five insurance companies are following Kooperativa pojišťovna, a.s. A_1, Generali Česká pojišťovna, a.s. A_2, NN Životní pojišťovna N.V. A_3, ČSOB Pojišťovna, a.s., člen holdingu ČSOB A_4, UNIQA pojišťovna, a.s. A_5. We analyzed data given by annual report of each insurance companies for period 2019–2021.

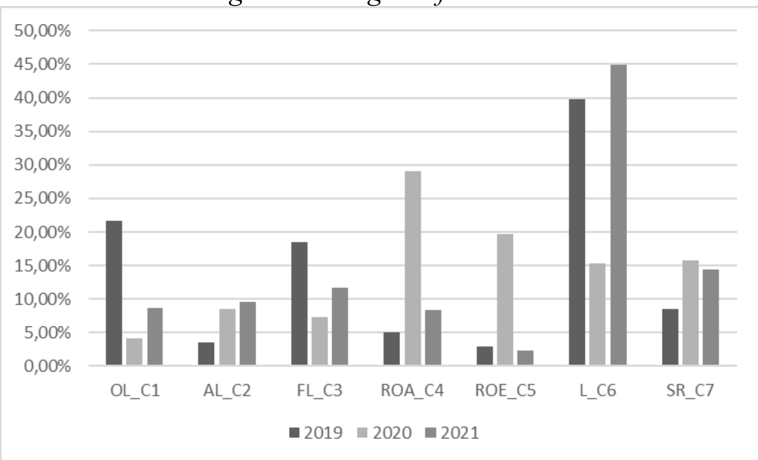
Standard decision matrix based on calculation of financial ratios by using of data from annual reports for period 2019-2021 for each insurance companies and the weights for each criterion can be possible to view in Table 2, Figure 1

[2] https://www.cap.cz/images/statisticke-udaje/vyvoj-pojisteno-trhu/STAT-2021Q3-CAP-EN-2021-10-26-WEB.pdf

Table 2: Decision matrix

	OL_C1	AL_C2	FL_C3	ROA_C4	ROE_C5	L_C6	SR_C7
2019							
A1	0,323153	2,214457	4,963266	0,038952	0,193328	0,456917	0,587984
A2	4,377752	4,110032	5,326798	0,026965	0,176577	0,221048	0,999506
A3	10,512250	2,854609	23,639904	0,015448	0,365183	0,463838	0,273541
A4	8,869488	3,640610	11,323287	0,027321	0,309364	2,659137	0,373512
A5	3,427689	1,787176	6,290974	0,046184	0,290543	0,267248	0,409440
w_{ij}	21,66%	3,52%	18,51%	5,07%	2,92%	39,81%	8,52%
2020							
A1	0,325472	2,108779	4,993344	0,032450	0,162032	0,588034	0,584849
A2	3,910332	3,230605	5,881971	0,041263	0,242708	0,287857	0,817452
A3	7,684115	2,871657	17,992054	0,016369	0,294513	0,531600	0,373473
A4	6,345286	3,675652	0,280008	0,034851	0,277161	1,354158	0,502932
A5	2,718981	1,290359	2,311330	0,044358	0,236929	0,575095	0,521973
w_{ij}	4,14%	8,58%	7,35%	29,13%	19,66%	15,38%	15,76%
2021							
A1	0,384969	2,000698	5,908987	0,103360	0,610750	0,465577	0,484989
A2	4,424072	3,520279	6,638914	0,070253	0,466402	0,902646	0,846825
A3	7,819451	2,702032	19,243641	0,015616	0,300518	0,411518	0,365233
A4	5,127952	3,620884	0,677425	0,022098	0,149739	29,810935	3,620884
A5	1,986644	0,091657	5,363574	0,027412	0,147027	0,203387	0,623401
w_{ij}	8,65%	9,62%	11,63%	8,32%	2,33%	44,98%	14,47%

Figure 1: Weights of criterion



According to the results we can see that the highest weight for 2019 and 2021 is cash ratio. In 2020 the first and second highest value is ROA, resp. ROE.

3.2 Application of TOPSIS method

Based on input data and determined weights we construct weighted normalized matrix by using equation 2.1 and subsequently 2.2.

Table 3: Weighted normalized decision matrix

	OL_C1	AL_C2	FL_C3	ROA_C4	ROE_C5	L_C6	SR_C7
2019							
A1	0,004716	0,011429	0,032906	0,026960	0,009125	0,065909	0,038146
A2	0,063890	0,021212	0,035316	0,018663	0,008334	0,031885	0,064844
A3	0,153418	0,014733	0,156728	0,010692	0,017237	0,066907	0,017746
A4	0,129443	0,018790	0,075071	0,018910	0,014602	0,383572	0,024232
A5	0,050024	0,009224	0,041708	0,031966	0,013714	0,038550	0,026563
2020							
A1	0,001220	0,029247	0,018617	0,119986	0,057685	0,053332	0,071216
A2	0,014653	0,021613	0,021930	0,152575	0,086406	0,026107	0,099540
A3	0,028794	0,039827	0,067082	0,060526	0,104849	0,048213	0,045477
A4	0,023777	0,024590	0,001044	0,128866	0,098672	0,122815	0,061241
A5	0,010189	0,008633	0,008618	0,164020	0,084349	0,052158	0,063560
2021							
A1	0,003158	0,031709	0,031427	0,065719	0,016742	0,007020	0,018377
A2	0,036296	0,055794	0,035309	0,044668	0,012785	0,013610	0,032087
A3	0,064153	0,042825	0,102348	0,009929	0,008238	0,006205	0,013839
A4	0,042071	0,057388	0,003603	0,014050	0,004105	0,449499	0,137199
A5	0,016299	0,001453	0,028526	0,017429	0,004030	0,003067	0,023621

Subsequently, we determined the positive ideal PIS and the negative ideal solutions NIS by using formula 2.3, resp. 2.4., see Table 4.

	OL_C1	AL_C2	FL_C3	ROA_C4	ROE_C5	L_C6	SR_C7
2019							
PIS	0,00472	0,00922	0,03291	0,03197	0,01724	0,38357	0,06484
NIS	0,15342	0,02121	0,15673	0,01069	0,00833	0,03189	0,01775
2020							
PIS	0,00122	0,00863	0,00104	0,16402	0,10485	0,12282	0,09954
NIS	0,02879	0,03983	0,06708	0,06053	0,05768	0,02611	0,04548
2021							
PIS	0,00316	0,00145	0,00360	0,06572	0,01674	0,44950	0,13720
NIS	0,06415	0,05739	0,10235	0,00993	0,00403	0,00307	0,01384

For results of ranking the performance of the insurance companies for the period 2019-2021, see Table 5. From the result, it is apparent that the best performance has ČSOB Pojišťovna, a.s., člen holdingu ČSOB for given period. The worst financial performance has NN Životní pojišťovna N.V. for 2019 and 2021 and UNIQA pojišťovna, a.s. for 2020

Table 5: Performance matrix of the TOPSIS

2019	Ranking R_i	2020	Ranking R_i	2021	Ranking R_i
A1	2	A1	3	A1	2
A2	4	A2	4	A2	4
A3	5	A3	2	A3	5
A4	1	A4	1	A4	1
A5	3	A5	5	A5	3

4. Conclusion

The goal of the paper was to evaluate financial performance based on financial ratio analysis of chosen insurance companies for period 2019-2021 via TOPSIS method.

Evaluation of financial performance is one of the basic activities for decision-making at micro and macro levels. As insurance companies play a significant role in financial system, it is necessary to consider warning signs. Financial performance was made through ratio analysis for different area by using the data of annual report. Evaluation of financial performance was made by using of TOPSIS:

Determination of weights an important part of MADM analysis. Changing weights may cause different ranking. Each MADM method has its own functionality, which can have an impact for overall ranking. For further research, the analysis can be extended by using different ratio and method for analysis of financial performance.

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What will be the development of the profitability of the Automotive industry in the Czech Republic?

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Abstract

This paper is dedicated to analysis of profitability of the Automotive industry of the Czech Republic. The Automotive industry is one of the key segments of the Czech industry. Last two years of COVID-19 have had an essential impact to the development of the profitability and financial performance of all segments of the industry. The aim of this paper is to analyze profitability of the Automotive industry in the period 2008 to 2020, as the most important industry of the Manufacturing industry. The Automotive industry of the Czech Republic is analyzed according to ROA indicator. In the end of the paper, prediction of the development of the profitability for year 2021 is calculated.

Key words

ROA, profitability, COVID – 19, financial performance

JEL Classification: G30, M0, O12, C6

1. Introduction

The Manufacturing industry belongs to the key segments of the Czech economy. The Manufacturing industry makes up approximately a quarter of the economy of the entire Czech Republic. It is possible to say that the development of the overall industry basically copies the development of the processing industry. There are number of studies that deal with the analysis of the Manufacturing industry, either from the point of view of competitiveness or the structure of companies operating in the Manufacturing industry. i.g. Richtarová, Ptáčková (2019), Rojíček (2006, 2010) or Žeňka (2009). The most dominant sector, within the Manufacturing industry, is the Automotive industry, which at the same time acts as a multiplier factor for the development of other related sectors. The importance of the Automotive industry is analyzed in previous research, Richtarová, Ptáčková, Borovcová (2020).

In last years, the economy of the Czech Republic, respectively of the whole world, has been affected by the pandemic situation of COVID-19. It is obvious that due to COVID-19 and thanks to the following war in the Ukraine, there are changes in the performance of each segment of the economy. The aim of this paper is to analyze the Automotive industry, as the most important industry of the Manufacturing industry, according to ROA indicator and to predict the development of profitability of the Automotive industry for one year. The article has a standard structure. Firstly, the Automotive industry is analyzed according to ROA indicator. Then pyramidal decomposition is applied and ROA indicator is decomposed into the indicator of profitability of revenues and the turnover of assets. Last part of the application is dedicated to prediction of ROA of the Automotive industry for the year 2021.

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2. Methods of the analysis

This part of the paper is dedicated to methods used for analysis. Firstly, ROA indicator as a measurement of profitability is characterized. Then method of pyramidal decomposition is briefly described. Lat part of the methodology is dedicated to the simulation Monte Carlo.

2.1 Return on Assets

Return on Assets (ROA) is one of the accountant indicators. It is a measure of how efficiently a company uses the assets it owns to generate profit. Managers, analysts, or investors use ROA indicator to evaluate a company's financial health. ROA is a helpful metric for measurement a single company's performance, Dluhošová (2010). When a firm's ROA rises over time, it indicates that the company is earning more profits out of each crown it owns in assets. On the contrary, a declining ROA suggests a company has made bad investments, is spending too much money, and may be headed for trouble.

ROA can be expressed in different ways. In this paper following formula is used for analysis of profitability of the Automotive industry of the Czech Republic.

$$ROA = \frac{EBIT}{A}, \tag{1}$$

where $EBIT$ is earnings before interest and taxes and A are assets.

2.2 Pyramidal decomposition

The pyramidal decomposition helps to identify the relationships between the financial indicators and, also to quantify the impact of component indicators on the base indicator, Dluhošová (2010). One of the main tasks of financial decision making is to analyze the deviations of component indicators and to find the factors that contribute the most to these deviations. Method of pyramidal decomposition is usually used for quantification of the impact of component ratios on the change in the base ratio. This method also allows to determine the interactions and relationships among the component ratios.

There are many ways, how ROA can be decomposed. In this paper, following decomposition is used for analysis of the Automotive industry of the Czech Republic.

$$ROA = \frac{EBIT}{R} \cdot \frac{R}{A}, \tag{2}$$

where R are revenues, $\frac{EBIT}{R}$ is the profitability of revenues and $\frac{R}{A}$ is the turnover of assets.

2.3 Simulation Monte Carlo

Financial assets are characterized by random development over time. It is known fact that future evolution of indicators is not deterministic. This process is referred to as a stochastic process and it can be described discretely with applications in simulations or continuously with use especially in analytical solutions, Gurný, Richtarová, Čulík (2017). The basic element of all processes is Weiner´s process, Zmeškal (2013).

A Wiener process is defined as

$$\tilde{z}_t - z_0 \equiv dz = \tilde{z} \cdot \sqrt{dt}. \tag{3}$$

Where $\tilde{z}$ is a random variable from a standardized normal distribution, $E(dz) = 0$ is mean value, $var(dz) = t$ is variance and $\sigma(dz) = \sqrt{t}$ is a standard deviation.

A special case of general process is a Brownian arithmetic process, sometimes also called a generalized Wiener process. This process is defined as follows

$$dx = \alpha \cdot dt + \sigma \cdot dz. \tag{3}$$

Parameters are constant and independent of other variables. The price is developing in a linear trend as

$$E(dx) = \alpha \cdot dt, \quad E(x_T) = x_0 + \alpha \cdot T, \quad var(dx) = \sigma^2 \cdot dt, \quad var(x_T) = \sigma^2 \cdot T. \quad (4)$$

Second case is the Brownian geometric process. In this case the price evolves with an exponential trend. This process has great application in financial modeling and is determined as follows,

$$dx = \alpha \cdot x \cdot dt + \sigma \cdot x \cdot dz. \quad (5)$$

It is clear, that this process is suitable for expressing the return and that indicates the average return, usually over a period of one year, and the standard deviation per year. The mean and variance can be determined as follows

$$E(dx) = \alpha \cdot dt, \quad E(x_T) = x_0 + \alpha \cdot T, \quad var(dx) = \sigma^2 \cdot dt, \quad var(x_T) = \sigma^2 \cdot T. \quad (6)$$

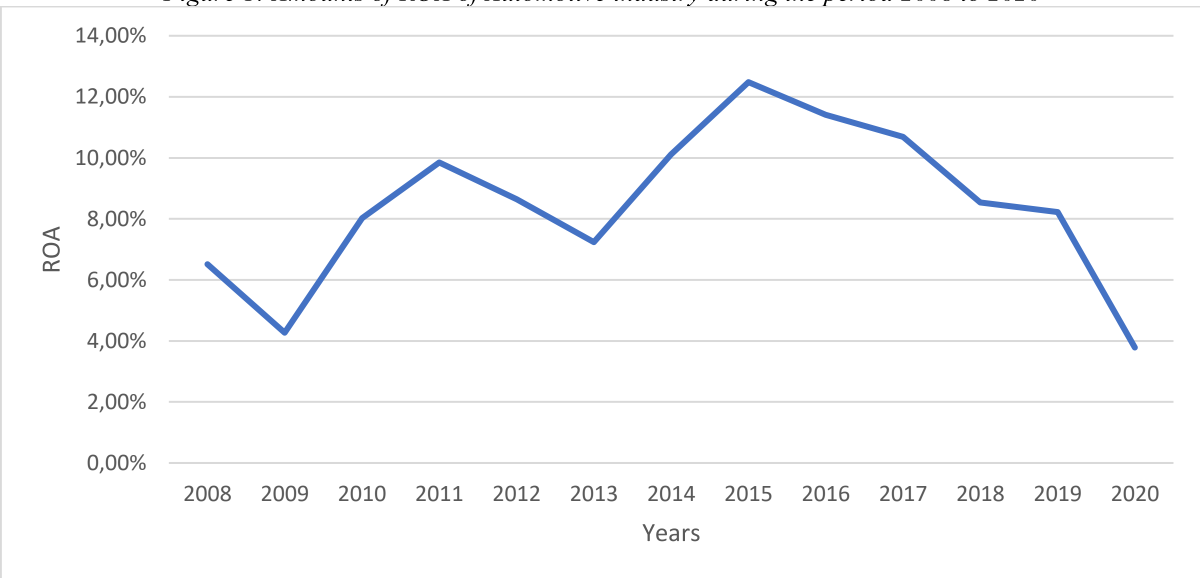
3. Application part

Application part of this paper is divided into two parts. First, analysis of ROA by pyramidal decomposition application in the Automotive industry of the Czech Republic during 2008 – 2020 is performed. Then, component ratios of ROA are considered in simulation model and ROA of the Automotive industry is predict for a year 2021.

3.1 Analysis of profitability of Automotive industry

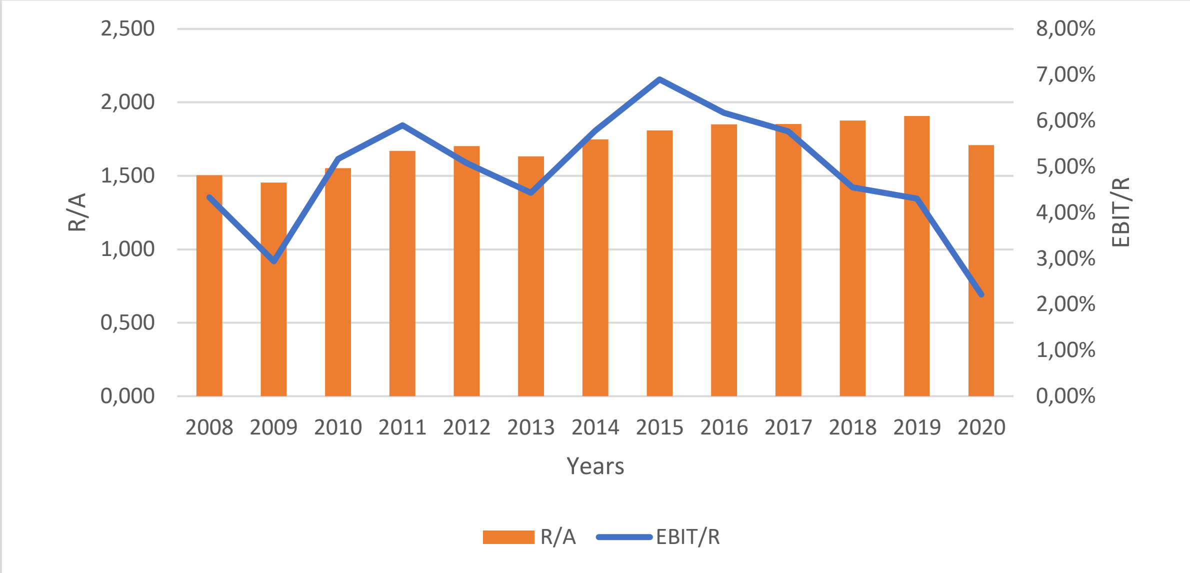
The data were taken from the website of the Ministry of Industry and Trade of the Czech Republic. Annual data are used for the analysis. In the Figure 1 there are amounts of ROA of the Automotive industry of the Czech Republic during the period 2008 to 2020.

Figure 1: Amounts of ROA of Automotive industry during the period 2008 to 2020



In 2009, the value of the ROA indicator decreased. EBIT fell by 37% and sales fell by only 8%. In 2010 and 2011, the increasing trend of ROA is caused by a significant increase in the EBIT indicator. Since 2011, the Return on Assets has been decreasing. Sales were up, but EBIT was down. In 2014, the Return on Assets of the automotive industry reached 10.11%, and the highest value for the entire analyzed period was reached in the year 2015. Since 2015, the Return on Assets has been decreasing. Since 2015, the Return on Assets has decreased to a value of 2.22% in 2020.

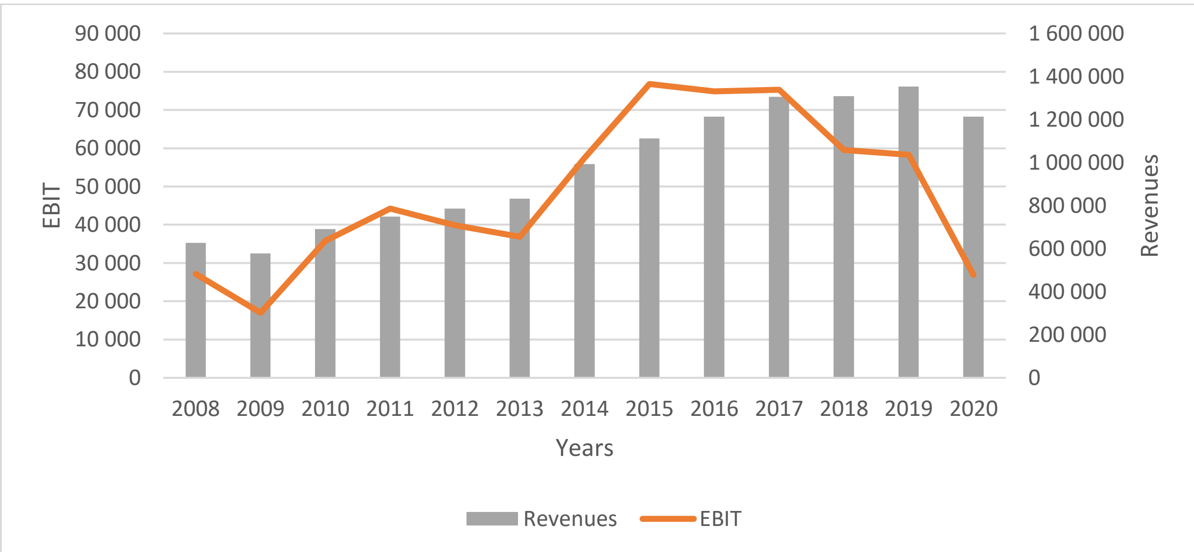
Figure 2: Amounts of EBIT/R a R/A of Automotive industry during the period 2008 to 2020



For a deeper analysis of the development of the ROA indicator, a pyramid decomposition is used. The ROA indicator is influenced both by the profitability of revenues and the turnover of assets. Both indicators should show an increasing trend.

Figure 2 shows that the profitability of revenues (EBIT/R) had a significant influence on the Return on Assets. This indicator changed significantly during the analyzed period.

Figure 3: Amounts of EBIT and revenues of Automotive industry during the period 2008 to 2020 (million CZK)



Return on Assets is mainly influenced by two factors, namely EBIT and revenues. Figure 3 shows the development of revenues and EBIT during the analyzed period. The value of revenues is increasing throughout the period, only in 2009 and 2020 revenues decreased. The decrease in revenues in 2020 was caused by the covid pandemic and, also by the lack of parts for the production of cars, especially chips. On the other hand, EBIT showed more significant changes during the analyzed period. In the years when ROA decreased, this decrease was primarily caused by a decrease in the EBIT indicator. Return on Assets reached the lowest value for the entire analyzed period in 2020, only 3.78%. This low value was caused by a significant drop in the EBIT indicator, which decreased by 54% compared to 2019.

3.2 Prediction of ROA in Automotive industry of the Czech Republic

The prediction od ROA of the Automotive industry of the Czech Republic is made for year 2021. The prediction is simulated according to Monte Carlo method. For the simulation annual data from the website of Ministry of Industry and Trade of the Czech Republic are taken. Firstly, component ratios are simulated and then ROA indicator is calculated.

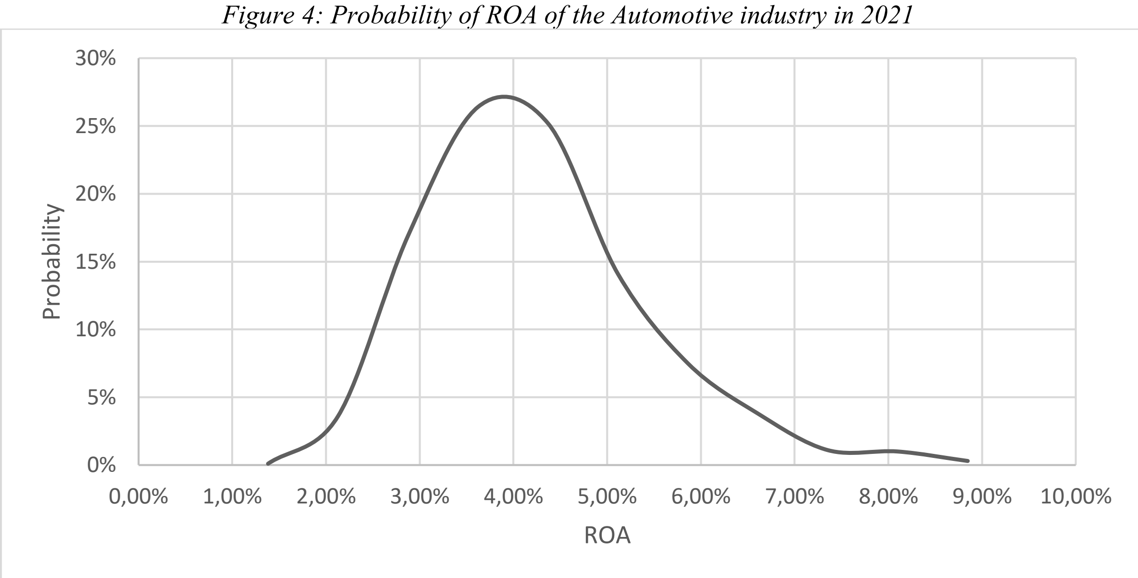
First, random numbers are generated from the normed normal distribution using the Pseudorandom Number Generator for 1000 random scenarios. Then, basic characteristics (mean, variance, and standard deviation) are calculated from continuous yields according to (6). Subsequently, prediction of component indicators is calculated according to (5). Mean, variance and standard deviation of component indicators are shown in the Table 1.

Table 1: Standard deviation, variance and mean value of component indicators

	EBIT/R	R/A
σ	0,30458	0,05017
σ^2	0,09277	0,00252
α	-0,05594	0,01064

From the table 1 it is clear, that the mean value of EBIT/R indicator is negative. It can be assumed that there will be a decreasing trend of profitability. Meanwhile the mean value of the R/A indicator is positive. The variance of the EBIT/R indicator is higher than the variance of the second component indicator. These basic characteristics are used for the prediction of component indicators according to a Monte Carlo simulation. The probability contribution of ROA is shown in the Figure 4.

Figure 4: Probability of ROA of the Automotive industry in 2021



From the results of the analysis, it is clear, that, with 25% of probability the value of ROA will be around 3.86%. There is a declining trend of ROA of the Automotive industry from the year 2015 to 2020. Official data for the year 2021 are not published yet, but it can be assumed that the profitability of the Automotive industry will be decreasing also in the year 2021. It is known that in the year 2021 some industries, i.g. the automotive industry as well as all the Manufacturing industry, were affected by the situation associated with the pandemic situation of COVID - 19 and this caused a problem with production and sales. Covid – 19 had a negative impact not only on the profitability of the Automotive industry, but as well on all segments of the Manufacturing industry. However, the economic situation has not improved and it can be predicted that the profitability of the Automotive industry as well as profitability of the Manufacturing industry will be affected by the war in the Ukraine and the trend will be still decreasing. This paper shows the prediction of profitability of the Automotive industry based on historical data and it will be appropriate to compare these conclusions with real data when they are published in the database of the Ministry of Industry and Trade of the Czech Republic.

4. Conclusion

This paper was dedicated to analysis of profitability of Automotive industry of the Czech Republic. The Automotive industry is part of the Manufacturing industry and is one of the most important segments of the Manufacturing industry of the Czech Republic. The current situation associated with the pandemic situation of COVID-19 affected all segments of the Czech Economy, industry and also services. The aim of this paper was to analyze Automotive industry during the period 2008 to 2020 and then to predict the development of profitability of the Automotive industry of the Czech Republic for the year 2021. Data for a year 2021 are not published yet, but it can be assumed that according to the situation affected with a COVID – 19 and subsequent war in the Ukraine, the decreasing trend will continue.

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Has the turbulent period affected the solvency of insurance companies at the Slovak insurance market?

Andrea Snopková, Zuzana Gajdošová[1]

Abstract

The Covid-19 pandemic affected almost all sectors of the Slovak economy, including insurance. The Solvency II regulation has been in force since 2016. It has changed many requirements, calculations, and statements that insurance companies have had to deal with. The aim of the Solvency II regulation is to implement solvency requirements that better consider the risks faced by insurance companies. It has also introduced a system of supervision that is comparable in all European Union Member States. The aim of the paper is to find out whether the Covid-19 pandemic affected the solvency of insurance companies at the Slovak insurance market. The intention was to find out whether insurance companies did not have a problem with the monitored indicator such as solvency even during such a turbulent period as the Covid-19 pandemic.

Key words

insurance, insurance company, solvency, Minimum Capital Requirement (MCR), Solvency Capital Requirement (SCR), Covid-19 pandemic

JEL Classification: G22

1 Introduction

The state regulates the insurance industry through laws and other legislation. It is based on the concept where regulation is the determination of rules for the behavior of economic entities. On the other hand, the supervision of insurance companies is performed by a designated supervisory institution, and it is a matter of controlling compliance with the rules set by the regulator. (Sivák, 2019) In Europe, insurance regulation is based on principles, while in the USA it is based on rules. While it is true that there are no principles without rules and no rules without principles. It is important to see that principles-based regulation is not equivalent to less regulation or deregulation. (The Geneva association, 2010)

One of the most serious problems of insurance companies is the inability of the insurance company to fulfill all its obligations arising from the signed insurance contracts. In the European Union (EU), insurance solvency requirements are regulated and strictly supervised. An important rule for the insurance industry is therefore Solvency II.

We are currently going through a turbulent period, with large fluctuations at various levels. Especially the period of the Covid-19[2] pandemic also examined the insurance market.

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[2] On 11 March 2020, the World Health Organization declared the Covid -19 pandemic. Subsequently, on 12 March 2020, the the Slovak government declared an emergency situation and took preventive measures in order to mitigate the effects of this pandemic. On 16 March 2020 the state of emergency was declared in the field of healthcare. It lasted until 13 June 2020. The state of emergency was declared for the second time from 1 October 2020, with repeated prolongation. It lasted more than

Therefore, it is interesting to see whether insurance companies have sufficiently well-established solvency requirements. This is important information for potential clients, policyholders, shareholders, credit rating agencies and others.

Solvency is often confused with the term liquidity. Especially for the field of insurance industry, it is important to know the difference between solvency and liquidity. Solvency in the insurance industry is defined by Fecenko and Strešňáková (2006) as *"the ability of an insurer to meet assumed insurance obligations, i.e., to pay justified insurance claims from insurance events. In general, the term solvency of commercial insurance companies means an indicator evaluating the insurance company's ability to pay all liabilities from taken out insurance even in the event of extraordinary events."* Pastoráková and Brokešová (2013) also define the solvency of the insurance company as "*the ability to provide own funds to settle liabilities arising from insurance contracts."* In contrast, liquidity is usually understood as *"the ability of an enterprise to convert its assets into funds that can be used to settle liabilities."* (Pastoráková, Brokešová, 2013) We can simply say that solvency in the insurance industry is the ability to repay its liabilities from insurance and reinsurance activities within agreed deadlines. Liquidity is the ability of an insurance company to convert its assets into cash. Liquidity is provided mainly from external sources such as insurance or technical provisions, but solvency from own resources.

2 Data and Methodology

The main goal of the paper is to find out whether the pandemic Covid-19 affected the solvency of insurance companies at the Slovak insurance market. This is a very important indicator that insurance companies must comply with. Otherwise, there are sanctions according to the degree of non-compliance.

The calculation of the Basic Solvency Capital Requirement shall include the risk module for intangible assets risk and shall be equal to the following:

$$BasicSCR = \sqrt{\sum\nolimits_{i,j} Corr_{i,j}.SCR_i.SCR_j} + SCR_{intangibles}$$

Source: Commission delegated regulation (EU) 2015/35

Where the factor $Corr_{i,j}$ denotes the item in row i and in column j in the correlation matrix.

Table 1: Correlation matrix

i/j	Market	Failure	Life	Health	Non-life
Market	1	0.25	0.25	0.25	0.25
Failure	0.25	1	0,25	0.25	0.5
Life	0.25	0.25	1	0.25	0
Health	0.25	0.25	0.25	1	0
Non-life	0.25	0.5	0	0	1

seven months, until May 14, 2021. Several measures were relaxed with the improving epidemiological situation. However, with the onset of further pandemic waves and depending on the characteristics of the virus variants, further measures have been taken to prevent their spread. The state of emergency was declared again from 25 November 2021, lasting until 22 February 2022. After reaching the peak of the omicron variant wave, the measures were released again.

SCR_i indicates risk module i a SCR_j indicates risk module j and where "i, j" means that all possible combinations of risk modules i and j should be included in the sum. In the calculation SCR_i a SCR_j are replaced by the variables:
$SCR_{non-life}$, which indicates the non - life underwriting risk module,
SCR_{life}, which indicates the life underwriting risk module,
SCR_{health}, which indicates the health underwriting risk module,
SCR_{market}, which indicates the market risk module,
$SCR_{zlyhanie}$, which indicates the counterparty failure risk module.

$SCR_{intangibles}$ indicates the capital requirement for the risk of intangible assets, which is 80% of the value of intangible assets valued under the Insurance Act. (Measure of the National Bank of Slovakia, 2015)

The data were collected from statements and reports on solvency and financial condition from 31st December 2016 - 2021 sent by insurance companies to the National Bank of Slovakia (NBS). The data were processed into tables. The solvency and minimum solvency ratio were determined based on the eligible own funds for each solvency. The solvency ratio is the ratio between the eligible own funds intended to meet the Solvency Capital Requirement and the Solvency Capital Requirement. The minimum solvency ratio is the ratio between the eligible own funds intended to meet the Minimum Capital Requirement and the Minimum Capital Requirement. The ratio above 100% means full compliance with regulatory requirements, strong financial position, and ability to meet assumed insurance obligations of the insurance company

3 Solvency II

All insurance and reinsurance companies operating in the EU are obliged to comply with the rules of Solvency II regulation. Prior to the introduction of this regulation, commercial insurance companies followed the Solvency I regime, which had its shortcomings. Mainly, it did not address all the risks associated with the activities of commercial insurance companies. That is why in 2009 the European Parliament adopted a directive known as Solvency II. The new Directive 2009/138 / EC of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II) entered into force in January 2016 and introduces a change in the regulation of insurance companies (those not excluded from the scope of the Directive). In Slovakia, it was implemented by Act no. 39/2015 Coll. on Insurance.

The main goals of the Solvency II are the unity of the EU insurance market, the transparency of EU legislation, the deepening of the protection of policyholders, but also the development of international competitiveness. (Vávrová, 2014) The introduction of the Solvency II regime brought with it many changes for insurance companies, for example in the drafting of legislation at the domestic market, the calculations for technical provisions changed, the need to introduce uniform solvency requirements and the determination of supervisory competencies.

Solvency II aims to reflect new approaches to risk management, capital requirements or even transparency. The framework for the calculation of capital requirements, namely the calculation of the Solvency Capital Requirement (SCR) and the Minimum Solvency Capital Requirement (MCR), is regulated in the Solvency II, and thus also in the Act no. 39/2015 Coll. on Insurance and the Solvency Measures Act.

The Solvency II concept is based on a three-pilar architecture. The first pillar describes the quantitative requirements for the calculation of SCR, MCR and technical provisions. The second pillar focuses on quality requirements and supervisory principles. The third pillar focuses on market discipline and disclosure. This system of regulation of the EU insurance market is determined to reveal, above all, the real financial situation of insurers, but also to increase the transparency of the EU insurance market. It captures all the risks affecting insurance companies comprehensively.

The calculation of capital requirements is based on a risk-oriented approach, if the failure of an insurance company (or reinsurance company) will occur with a probability of 0,5% within one year. The SCR calculation considers all material and quantifiable risks, namely market risk, counterparty failure risk, life, non-life and health insurance underwriting risk, intangible assets risk and operational risk. (Gondová, 2015) The minimum amount of eligible own funds that a company must have to be able to continue its insurance activities without restriction is generally referred to as the solvency margin or Solvency Capital Requirement.

MCR represents the lowest acceptable limit of the insurance company's capital ensuring the ability to absorb unexpected losses in one year reliably 88.5%. The main principles of MCR calculation are simplicity and auditability. Due to the sensitivity of the MCR value to the risks of linear calculation, a lower limit of 25% of the SCR and an upper limit of 45% of the SCR are introduced. At the same time, the absolute minimum MCR is set. The frequency of the calculation is quarterly, and the result is announced to the NBS. (Gondová, 2015) The minimum solvency ratio of the required regulator is 100%. It shall have an absolute floor of:

a) 2 500 000 EUR for non-life insurance undertakings, including captive insurance;
b) 3 700 000 EUR for life insurance undertakings, including captive insurance;
c) 3 600 000 EUR for reinsurance undertakings; except in the case of captive reinsurance undertakings, in which case the Minimum Capital Requirement shall be not less than EUR 1 200 000;
d) if the insurance undertaking carries on both life and non-life at the same time, the absolute lower limit of the Solvency Capital Requirement shall be determined at the sum of the sums referred to in (a) and (b). (Measure of the National Bank of Slovakia, 2015)

3.1 Solvency requirements at the Slovak insurance market

According to data from the NBS, there are currently 10 insurance companies and 17 branches of insurance companies from another Member State at the Slovak insurance market. An overview of insurance companies is shown in Table 2. In our research, we will focus only on insurance companies and not on branches of insurance companies from another Member State.[3]

Table 2: Insurance companies at the Slovak insurance market according to market share

No.	Name of insurance company
1.	Allianz - Slovenská poisťovňa, a.s.
2.	BNP Paribas Cardif Poisťovňa, a.s.
3.	ČSOB Poisťovňa, a.s.
4.	KOMUNÁLNA poisťovňa, a.s. Vienna Insurance Group
5.	KOOPERATIVA poisťovňa, a.s. Vienna Insurance Group
6.	NN Životná poisťovňa, a.s.
7.	NOVIS Insurance Company, NOVIS Versicherungsgesellschaft, NOVIS Compagnia di Assicurazioni, NOVIS Poisťovňa a.s.
8.	PARTNERS poisťovňa, a.s.
9.	Wüstenrot poisťovňa, a.s.
10.	Union poisťovňa, a. s.

Source: NBS (1)

[3] In 2021 the UNIQA poisťovna, a.s. and Generali poisťovňa, a.s transformed into branches of insurance companies from another Member State.

Within insurance companies and market shares, Allianz - Slovenská poisťovňa, a.s. has the largest market share, followed by KOOPERATIVA poisťovňa, a.s. Vienna Insurance Group, followed by KOMUNALNA poisťovňa, a.s. Vienna Insurance Group, NN Životná poisťovňa, a.s. and ČSOB Poisťovňa, a.s .

Table 3: Solvency ratio and minimum solvency ratio for insurance companies at the Slovak insurance market from 2016 to 2021, in thousands euro

Year	2016	2017	2018	2019	2020	2021
Total eligible own funds intended to meet SCR	1 387 365	1 341 479	1 311 622	1 479 663	1 598 201	1 358 174
Total eligible own funds intended to meet MCR	1 387 365	1 341 479	1 294 855	1 479 520	1 595 127	1 353 593
SCR	604 773	666 843	691 806	765 148	836 231	671 308
MCR	242 854	258 246	268 460	288 660	299 999	256 125
Solvency ratio	229.40%	201.17%	189.59%	193.38%	191.12%	202.32%
Minimum solvency ratio	571.28%	519.46%	482.33%	512.55%	531.71%	528.49%

Source: NBS (2)

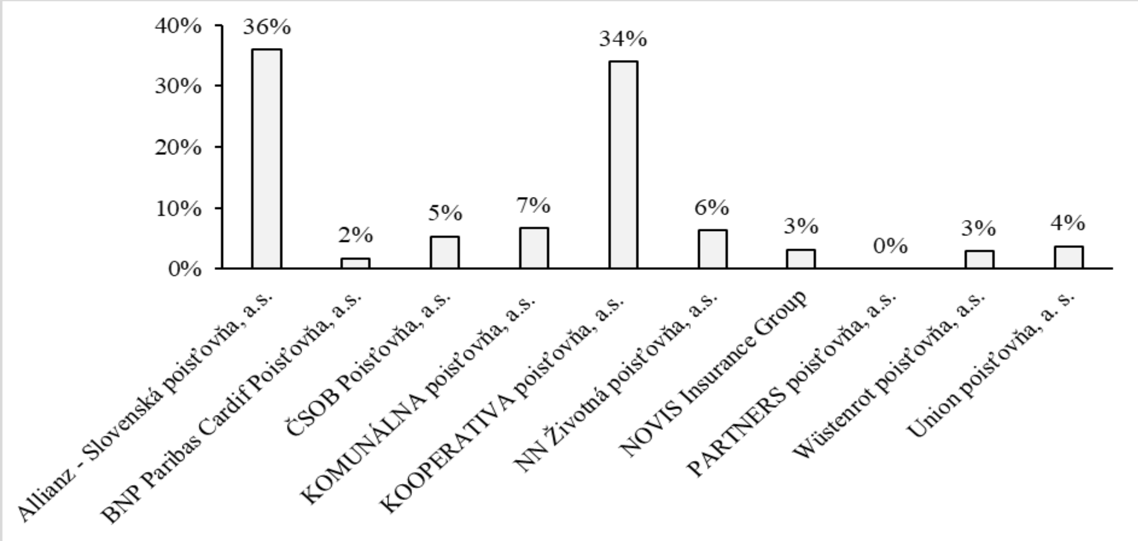
We can see from the calculated minimum solvency ratio, that insurance companies at the Slovak insurance market exceed the required limit of 100% several times. It follows that insurance companies adhere to the lowest acceptable limit of capital of insurance companies ensuring the ability to absorb unexpected losses and even 5 times more. If we look at the given indicator from the point of view of individual years, we see that even the Covid-19 pandemic (starting in Slovakia in 2020) did not cause any problem for insurance companies. The ratio between the eligible own funds intended to meet the Minimum Capital Requirement and the Minimum Capital Requirement has hardly changed as well.

The second important indicator to be monitored is the solvency ratio. We also see the similar trend with this indicator as with the previous indicator. The ratio between the eligible own funds intended to meet the Solvency Capital Requirement and the Solvency Capital Requirement was almost doubled. This means that insurance companies do not have a problem with solvency even during more demanding years, where the slumps in the financial markets are very large. If we look at the years of the pandemic (2020 and 2021), we can see that the total eligible own funds intended to meet the Solvency Capital Requirement represents 1 598 201 ths. EUR resp. 1 358 174 ths. EUR, which leads to a solvency ratio of 191.12 % resp. 202.32 %. This indicator far exceeds the regulatory minimum of 100%. The minimum solvency ratio was in 2020 531.71 % and in 2021 528.49 %.

3.2 Comparison of solvency requirements in selected insurance companies

In the previous section, we looked at the solvency requirements together, for all 10 insurance companies operating at the Slovak insurance market. Subsequently, we will analyze the largest insurance companies according to their share at the Slovak insurance market. We will consider gross written premiums for the period from 2016 (when the Solvency II entered into force) up to 2021. (Figure 1)

Figure 1: Insurance companies according to the share at the Slovak insurance market 2021



Source: Solvency and financial condition reports of individual insurance companies

Four of the analyzed insurance companies have the universal business scope and NN Životná poisťovňa, a.s. is oriented only for life insurance. Some insurance companies use so-called volatility adjustment, for example, the long-term investment horizon of assets covering insurance liabilities. Not all insurance companies use the correction, so for better comparison, we will rely on data sent by insurance companies to the NBS. Insurance companies do not use volatility adjustment or cease to use it gradually. The reason is that the impact on the solvency ratio is not significant. The values of the largest insurance company according to its share at the Slovak insurance market Allianz - Slovenská poisťovňa, a.s. could be seen in the Table 4.

Table 4: Solvency ratio and minimum solvency ratio of Allianz - Slovenská poisťovňa, a.s., in thousands of euros

Year	2016	2017	2018	2019	2020	2021
Eligible own funds for SCR	401 877	295 461	338 367	380 434	397 572	398 423
SCR	194 194	191 556	191 711	209 423	214 912	225 158
Solvency ratio	206.95%	154.24%	176.50%	181.66%	184.99%	176.95%
Eligible own funds for MCR	401 877	295 461	338 367	380 434	397 572	398 423
MCR	79 007	81 163	86 270	94 240	96 710	97 873
Minimum solvency ratio	508.66%	364.03%	392.22%	403.69%	411.10%	407.08%

Source: The solvency and financial condition report for individual years and statements sent to the NBS

The following the Table 5 presents the solvency ratio and minimum solvency ratio for the second largest insurance company KOOPERATIVA poisťovňa, a.s. Vienna Insurance Group.

Table 5: Solvency ratio and minimum solvency ratio of KOOPERATIVA poisťovňa, a.s. Vienna Insurance Group, in thousands of euros

Year	2016	2017	2018	2019	2020	2021
Eligible own funds for SCR	331 032	316 737	321 127	336 472	412 947	491 510
SCR	128 783	134 975	182 691	205 146	201 811	190 332
Solvency ratio	257.05%	234.66%	175.78%	164.02%	204.62%	258.24%
Eligible own funds for MCR	331 032	316 737	321 127	336 472	412 947	491 510
MCR	41 428	41 021	60 184	63 836	69 844	68 637
Minimum solvency ratio	799.05%	772.13%	533.58%	527.09%	591.24%	716.10%

Source: The solvency and financial condition report for individual years and statements sent to the NBS

Based on the processed data of KOMUNÁLNA poisťovňa, a.s. Vienna Insurance Group the solvency ratio and minimum solvency ratio is presented in the Table 6.

Table 6: Solvency ratio and minimum solvency ratio of KOMUNÁLNA poisťovňa, a.s. Vienna Insurance Group, in thousands of euros

Year	2016	2017	2018	2019	2020	2021
Eligible own funds for SCR	50 184	50 890	53 796	62 088	68 351	81 223
SCR	30 524	35 260	38 450	44 012	41 265	39 629
Solvency ratio	164.41%	144.33%	139.91%	141.07%	165.64%	204.96%
Eligible own funds for MCR	50 184	50 890	37 378	62 088	68 351	81 223
MCR	11 591	12 814	14 034	13 575	13 351	13 115
Minimum solvency ratio	432.96%	397.14%	266.34%	457.36%	511.95%	619.31%

Source: The solvency and financial condition report for individual years and statements sent to the NBS

The fourth largest insurance company is NN Životná poisťovňa, a.s. It is interesting to see the situation in this only life insurance company. The solvency ratio and minimum solvency ratio for the insurance companies is shown in Tables 7 and 8.

Table 7: Solvency ratio and minimum solvency ratio NN Životná poisťovňa, a.s., in thousands of euros

Year	2016	2017	2018	2019	2020	2021
Eligible own funds for SCR	61 265	64 447	56 468	154 716	192 521	202 767
SCR	26 080	30 793	39 431	57 039	102 211	98 885
Solvency ratio	234.91%	209.29%	143.21%	271.25%	188.36%	205.05%
Eligible own funds for MCR	61 265	64 447	56 468	154 716	192 521	202 767
MCR	11 736	13 511	12 555	14 260	25 553	24 721
Minimum solvency ratio	522.03%	477.00%	449.77%	1084.96%	753.42%	820.22%

Source: The solvency and financial condition report for individual years and statements sent to the NBS

NN Životná poisťovňa, a.s. differs from the previous 3 insurance companies. As could be seen in the Table 7m there are significant fluctuations in the values. In 2019, the solvency ratio reached 271.25% and the minimum solvency ratio reached 1 084.96%. Both indicators increased due to an increase in usable own funds. In 2019, the solvency ratio of NN Životná poisťovňa, a.s. increased compared to 2018 from 143.21% to 271.25%. Mainly because they merged with AEGON Životná poisťovňa, a.s. Value AEGON Životná poisťovňa, a.s. was reported as an equity interest in the balance sheet, but only the equity risk arising from this equity interest was included in the capital requirement. Subsequently, the merger in the first quarter of 2020 included the entire portfolio in the capital requirement. That is why they got to the values in 2021. (The solvency and financial condition report of NN Životná poisťovňa, a.s., 2019 and 2020)

Table 8: Solvency ratio and minimum solvency ratio ČSOB Poisťovňa, a.s., in thousands of euros

Year	2016	2017	2018	2019	2020	2021
Eligible own funds for SCR	70 502	65 381	69 939	52 741	56 040	55 375
SCR	23 451	26 208	22 713	26 900	29 283	30 128
Solvency ratio	300.64%	249.47%	307.92%	196.06%	191.37%	183.80%
Eligible own funds for MCR	70 502	65 381	69 939	52 741	55 874	54 147
MCR	10 184	10 805	10 221	12 105	13 177	13 558
Minimum solvency ratio	692.28%	605.10%	684.27%	435.70%	424.03%	399.37%

Source: The solvency and financial condition report for individual years and statements sent to the NBS

Based on the performed analysis, we can conclude that none of the insurance companies had a problem with either the Minimum Capital Requirement or the Solvency Capital Requirement in 2016 – 2021. They even exceeded the required limit several times. The Covid-19 pandemy years 2020 and 2021 did not bring a change either, where the pandemic affected almost all sectors of the Slovak economy, insurance sector not excluded.

4 Conclusion

The Covid-19 pandemic and measures against its spread have significantly affected several economic sectors, including insurance. Significant risks associated with the pandemic for insurance companies were mainly measures that dampened tourism. Due to the decline in travel insurance, revenues from this type of insurance decreased significantly. This was followed by the risk associated with an increased likelihood of travel agencies going bankrupt. Especially in case of insufficient state aid to this sector. The pandemic has caused that insurance companies significantly tightened the conditions for underwriting certain risks. Another area was the area of operational risk due to the transition of the operation to the way of working from home. On the other hand, the pandemic also had a positive effect on insurance companies. For example, people traveled less during the Covid-19 pandemic. It was reflected in motor insurance claims. The impact of the pandemic was also recorded by the higher demand for insurance due to an increase of mortality rate. We can say that the impact of the pandemic on insurance companies was either positive or negative.

In the article, we focused on solvency indicators on the Slovak insurance market. The reporting of solvency by insurance companies is of great importance from a practical point of view. It is a legislatively confirmed methodology of the insurance company's ability to fulfill its obligations. The purpose of this process is to verify and ensure that insurance companies are able to fulfill all their obligations not only now, but also in the future. Solvency monitoring should not be just bureaucracy for insurance companies. On the contrary, objective reporting of data on the insurance company's solvency is important for all financial market participants. Therefore, insurance companies should pay more attention to this fact. That is also why we focused on the solvency of insurance companies. From our point of view, this is an important indicator. We looked at the Slovak insurance market, where we focused on the most important insurance companies and their fulfillment of solvency indicators even in a turbulent period such as the pandemic. We can conclude that there was no impact on meeting the capital requirements. Insurance companies reported several times higher the Minimum Capital Requirement as expected by Solvency II and the same case was for the Solvency Capital Requirement. Therefore, stagnation of the insurance sector cannot be expected even in the event of unexpected events.

The analysis shows that the capital requirements for insurance companies fluctuated more at the beginning, which is also due to the refinement of calculations, especially in the first two years after the transition to the new conditions of Solvency II.

The developement of insurance companies´ solvency also depends on possible measures by world economies, especially by the EU Parliament and the Slovak government to avert the consequences of the Covid-19 pandemic. The situation is constantly monitored. Currently, no significant impact on insurance companies´ solvency is expected due to a pandemic. But the Covid-19 pandemic is not over yet.

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Operational risk of accounting digitalization

Ján Vlčko, Jitka Meluchová[1]

Abstract

Digitalization of documents for official purpose rises several concerns for the users of document and for the regulatory authorities that need to be well managed to avoid any misconceptions. Usage of digital documents for official purpose must be well standardised and the processes of handling digital documents must be well managed. The goal of this paper is to show how organisations apply newly allowed option to use of digital documents in their daily accounting operations. Examining internal processes by interviewing accounting dept. employees and by on-site observations, this study shows that the processes of handling digital documents could be well managed and operational risks could be mitigated. Despite of lack of standardisation in digitalization and despite of lack of official guidance, and official legal explanations and best-practices, the application of document digitalization bring advantage of manhour savings and operational expenses savings.

Key words

Accounting, digitalization, Operational risk, management.

JEL Classification: M41; M48; O14

1 Introduction

Digitalization of accounting is a trend of processing of accounting nowadays and in the coming future not only in developed economies, but also in emerging markets. [3] By the term "Accounting" different meanings occur, depending on circumstances, situations, information, etc. Financial accounting is mostly well regulated in legislation or accounting standards. While International accounting standards are forms of guidance without concrete forms of accounting, the national accounting laws are strict set of rules, and forms of accounting. Purpose of accounting is not dealing with digitalization. Purpose of financial accounting is to provide fair presentation of financial statements. [10], purpose of management accounting is to provide useful information to the management of the company. Digitalization is just a tool to achieve the purpose of accounting. [13]

1.1 Legal background in Slovakia

Accounting is strictly regulated by accounting law [18] and Ministry of Finance regulations, which gave just a little space for any deviations. Digitalization, or better, handling of digital documents, namely invoices, have been allowed first by a VAT act [16]. Despite of it have allowed handling of digital originals of documents, the accounting act required some obstacle requirements which oppose digitalization, for example: need of two signatures on each accounting document, in case of investigation, the accounting unit had to prove that digital version of the document is identical with the paper original by showing paper original, etc. Despite of these obstacles, the trend of exchange of digital versions of invoices between companies emerged. Therefore, even accounting act had to be updated to allow processing and storage of digital accounting documents. Such update took place on 1st January 2022; from this

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date digitalisation of accounting documents is not only allowed but it is also regulated and, in many companies, even welcome.

In Slovakia, accounting is strongly bounded by taxation laws, mostly by Income tax act and VAT act, which affect accounting by some rules they dictate [14]. Therefore, each company must consider also effect of digitalization to its tax obligations and tax reporting. In Slovakia, Tax administration is appointed to investigate both, tax investigation and accounting investigation, that is the reasoning why accounting is so strongly bounded with the taxation laws. Another example of strong bounding is amendment of accounting act allowing digitalisation since 1st January 2022, which took some requirements and definitions described and used in VAT act namely 3 rules that must be met when a document is digitalised or digitally stored:

- Integrity of the content. This rule requires digitally converted document to contain the same content as original paper document and vise-versa.
- Credibility of origin. The credibility of origin must be proved by a company during the tax investigation or accounting investigation. The company must adopt either internal verification and double check procedures or any other rules or procedures to be able to show credibility of origin of the digitally stored documents. This rule is tricky to adopt as it is not clear what would be accepted as sufficient procedure to meet the goal. For cashier receipts the credibility of origin is easily verifiable by QR code that must be placed on every receipt and which links to Tax administration servers on which each receipt is digitally online stored. For invoices no such solution is yet in place but is proposed to be implemented in the near future [12].
- Readability with the naked eye. Each digitally stored document must be readable by a human. It means it cannot be stored solely only in some structured format such as XML, but it must be either stored in paper-like appeared digital document, for example in PDF, or it must be easily transferable into such appear.

1.1.1 Legal risks of digitalization of accounting in Slovakia

As digitalisation of accounting have been allowed in practice just recently, there is significant legal risk coming from the incorrectly performed handling, storing, and booking of digital accounting documents. As mentioned before, accounting and especially tax rules focus rather on formalities then on substance what is opposed to accounting principle strongly present in IFRS: substance over the form [8]. It is still required to meet all formal requirements to get tax acceptance of expenses and to perform accounting according to law. For not performing accounting according to the law the fine can be up to 2% of the asset value. The legal risk decreases for non-for-profit organisation (further as NGOs) which do not have taxable income as they are not subject to income tax investigation, but accounting law still applies even for them. Not performing accounting according to the law is a criminal offence [17]. Performance of accounting based on paper document is a historically well established, but performance of accounting based on digital documents is something new. There is also lack of standards and standardization of digital documentation which rises concerns how and whether digital documents used today will be readable and verifiable in the future after several years. For example, digital signatures issued by government, using ID cards, are using certificates with limited time of expiry. After this period new certificate must be issued. But digitally signed documents whose certificate had been expired must be capable to be verified whether the signature certificate was valid at the time of signing. For example, when company has adopted digital signing procedure of documents, it must be able to provide verification of validity of such signature backwards in time to the time of signing a document. Such details are important to be implemented when company decides to use digital documentation instead of paper documentation.

Another legal risk is that investigation authorities must be able to handle digital documents for the whole legal archiving period. Most of the accounting documents must be archived for 10 years, but some up to 70 years. Company must implement procedures to keep those digital documents available for the whole period of archiving. This paper focuses only on part of the process of digital document handling which is importing into software for further processing. For the whole process of accounting digitalisation, a whole monography would be needed.

Special focus must be given to fulfil non-accounting rules which affect the handling of digital documents, for example: GDPR, tax secret, business secrets, etc. Company must comply also with these rules as their breach results not only to reputational loss but also to significant fines and possible criminal charge. Therefore, there must be procedures, dedications, authorisations etc in place to ensure only appropriate people has access to certain documents at certain time and certain conditions. Logging of document handling is necessary.

1.2 Background in EU

As EU is built on 3 pillars: free movement of people, free movement of goods and free movement of capital [11], there is need for harmonisation of both accounting rules and taxation rules to enable companies to operate outside the borders of their origin countries. Unfortunately, each country deals with digitalisation on its own, with limited guidance of any EU regulation in place. [15]. Some minor activities have been made, but the effect is questionable. [6] For companies rises effort to meet requirements of each country where they operate in. Some fresh air into this situation comes with globally used ERP systems, used in multinational companies and markets. Such systems are capable not only to process digital documents but also to provide digital information exchange both business to business (further as B2B) and business to government (further as B2G). Example of B2G information exchange is online reporting of issued cashier receipts, which are implemented in several countries, and online invoicing reporting to tax administration.

1.3 Risk management

Digitalization of accounting requires implementation of internal procedures especially for verification of documents and verification of conversion from paper to digital format. For such procedure implementation of Risk management is needed. Guidance may be provided by for example ISO 31000 Risk management. "The risk management process involves the systematic application of policies, procedures and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risk." [9].

Users of financial statements rely on audit to ensure accounting is made correctly. Management may also rely on audit to ensure accounting is made correctly. But the role of audit is not to check whether accounting is correct, the role of audit is to ensure financial statements are correct. Such overestimated expectational gap [4] on audit shall not be used to decrease role of internal verification procedures and risk management within the company.

1.4 Advantages of accounting documents digitalization

Accounting digitalization increases company productivity. [7] Digital documents are much better to handle as they have no physical volume, no space, no weight. They can be easily transferred electronically to almost any place on Earth and they can be easily copied keeping their original parameters. Such properties are advantageous especially when documents are gathered at branches and accounted at HQ or at accounting supplier. Previously, physical documents had to be transported or sent to HQ for further processing. This is costly and increase risk of damage or lose of documents. Especially if the volumes of documents are significant. Nowadays, documents can be uploaded into software at the branches and available at HQ for further processing immediately without any losses or damages.

Once document is uploaded into software, it is available not only for accounting and further processing. It is also available to whoever needs it. For example, any other department than accounting department may need to use accounting documents for their operations. Also, audit can use electronic documents for the purpose of the audit what provides less time spent in the audited company as most of the audit work can be made from the auditor's office.

Reporting to authorities and grands is also easier when the documents are electronically stored in accounting software. Many times, subsidies, grants, and similar financial transfers must be properly reported including copies of the original accounting documents such as invoices, receipts, and contracts. Searching for documents in physical files, scanning or copying of document is time consuming. It is significant effort decrease when documents are just exported form the software to the reporting receiver.

Digitalization of accounting documents rise IT expenses. Company must consider whether the increased expenses are sufficient to the benefits and manhour decrease savings. In general, we can observe trend of digitalization not only in accounting but in business at all. [5]

2 Methodology

On sample of 5 real organisations, which already implemented digitalization in severe stages, we examined process of digitalization using observation, interviews, and analysis. Each entity was challenged by interviews with accounting department employees or an organisation accountant to describe process of digitalization and to describe how operational risks are mitigated. Gathered information was synthetized into the conclusion.

As the process of digitalization must be covered in internal regulations of an entity and as the digitalization was established just in 2022, it has no sense to challenge internal regulations with practice whether there are any differences. This research does not cover digital information exchange between enterprises (B2B) or between enterprise and government (B2G). Software update costs are negligible. Each organisation already had implemented accounting software or ERP software of which digital documents use is just an upgrade of the existing IT infrastructure. The advantage that matters is manhour savings and new features in daily operations that increase productivity [13].

2.1 Brief overview of the sample

Sample was taken considering different level of document volume handling and different number of branches. Each branch is in different address, therefore handling, processing and transportation of physical or digital documents between branches and HQ need to be considered. As the data are taken form real entities and are subject to trade secret, we use labels instead of real names. In the sample there are 3 NGOs. NGOs are more likely to adopt digitalization of accounting documents in Slovakia because they are not subject to taxes, the risk of tax laws compliance is significantly decreased for NGOs. Public services, in general, are subjects of implementing accounting digitalisation. [2] In the other hand, large companies are more likely to adopt to digitalization, as they already use some available ERP system, [13] which can be adjusted or upgraded to be able to cover also accounting documents digitalization. Despite of lack of the coverage of the digitalization of document in IFRS, companies who already submit their financial statements according to IFRS are more likely to adopt to digitalization of accountancy as they also use ERP. Even smaller enterprises who are part of consolidation must disclose their statements according to IFRS [1].

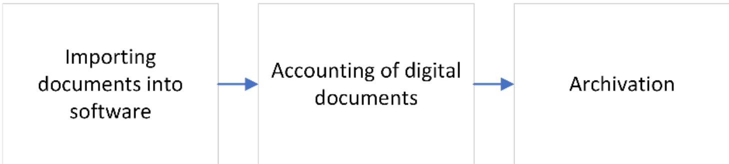
Table 1 Brief overview of the sample

Entity	Legal form	No. of employees	Yearly turnover	No. of branches
1	NGO	28	699 000 €	7
2	NGO	10	767 000 €	5
3	LTD	2	39 000 €	1
4	PLC	36	3 580 000 €	3
5	NGO	8	250 000 €	3

3 Results

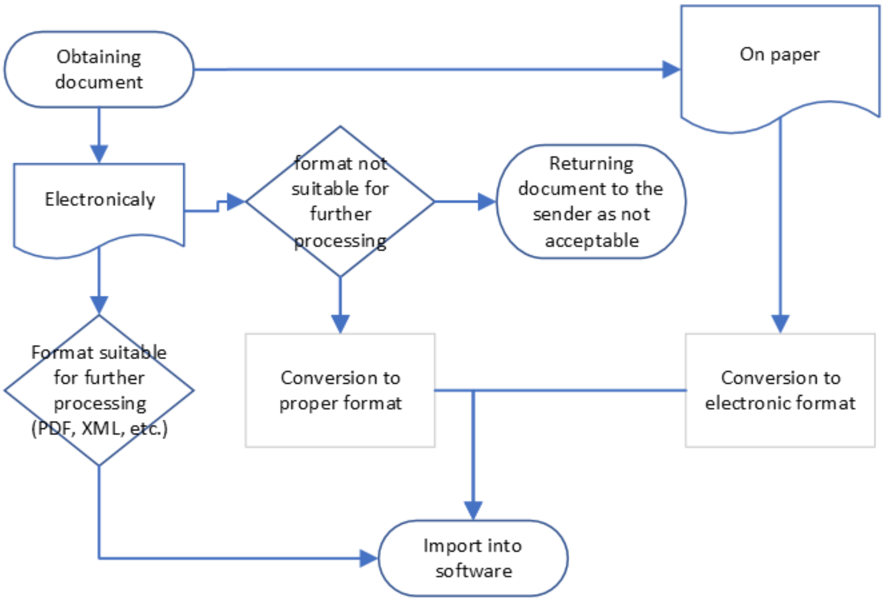
Despite of some minor differences among each entity, in general, the process of documents digitalization can be described in *Figure 1*.

Figure 1 Handling of digital documents for accounting purpose.



Each of these 3 steps is covered separately. For the purpose of this research, we will focus only on 1st step: Importing documents into software, which is described by separate chart in *Figure 2*. Whole process described in *Figure 2* is performed at the branch. Already imported document in software is then processed-accounted at the HQ.

Figure 2 Process of importing digital documents



For the evaluation of risks, we use risk matrix applying traffic light method of 3 levels: high, medium, and low. Traffic light method is used also on evaluation of occurrence of the risk. Traffic light method is used due to lack of data. Evaluation is made using expertise opinion gathered from the on-site employees. Example of Risk matrix for Entity no. 1 is in *Table 2*. Similar Risk matrix table had been filled out by employees in each entity.

Table 2 Overview of risk matrix for entity no. 1.

1	Risk description	Risk evaluation	Risk types	Consequences in case of occurrence	Mitigation
Risk 1	Document is not obtained or lost	low	Operational risk	Not acceptance of tax expense.	Internal procedure to match each supply to an invoice. Regular supplies such as electricity, rent, etc. are checked by a check list.
Risk 2	Fraudulent document is obtained	low	Operational risk	Financial loss, not acceptance of tax expense, Legal procedures.	Each received invoice must be confirmed by a dedicated person prior to accounting.
Risk 3	Document contains incorrect information	low	Operational risk	Not acceptance of tax expense.	Each received document must be confirmed by a dedicated person prior to accounting.
Risk 4	Electronic document is omitted.	low	Operational risk	Reputational injury, Interest rate for late payment. Fine for late tax reporting.	No mitigation. In case of omission of an invoice a notice will be delivered from supplier. Each payment must be matched with a document.
Risk 5	Electronic document is not suitable for processing	low	Operational risk	Not processed document may lead to corrupt accounting and financial statements	Sender of the document is asked to send documents in proper format, otherwise no payment is made.
Risk 6	Electronic document is in data format (XML, etc.)	medium	Operational risk	Inability to convert into readable format exclude it from accounting and tax acceptance	PDF version of XML origin are stored electronically.
Risk 7	Conversion does not meet credibility of origin	high	Operational risk	Inability to convert into readable format exclude it from accounting and tax acceptance	Receipts contain QR code which is used for verification of their origin. For other documents and invoices Risk is accepted as Tax administration has power for cross-check investigation.
Risk 8	Electronic document is unreadable by eye	low	Operational risk	Not acceptance of tax expense.	Each electronic document is accounted by an accountant who needs to read the document before accounting.
Risk 9	Conversion losses content	medium	Operational risk	Not acceptance of tax expense.	No mitigation. Invoices and all their attachments are scanned.
Risk 10	Import into software fails	low	Operational risk	Loss of documents.	Accounting is performed at HQ. In case of import fail at a branch, Branch is contacted to perform import again.
Risk 11	Import into software is not correct	low	Operational risk	Corrupted data may cause corrupt accounting and corrupt statements - fines are material	Accounting is performed at HQ. In case of corrupted import at a branch, Branch is contacted to perform import again.

For each entity, risk evaluation has been recorded and briefly processed into *Table 3*. As shown in *Table 3*, risk of not receiving or losing a document varies among the sample, while risk of obtaining false/fraudulent document is low in every entity from the sample. The result of evaluation is influenced by the fact that documents are gathered at the branches while accountancy is performed in HQ. Such process provides higher stress on branches, while HQ is capable of double check of the content of documents. In case of any doubt, there is still possibility to contact the branch for further explanation or correction.

Table 3 Risk evaluations for each entity.

Entity	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8	Risk 9	Risk 10	Risk 11
1	low	low	low	low	low	medium	high	low	medium	low	low
2	medium	low	medium	medium	medium	low	high	low	high	low	low
3	low	low	low	low	low	low	high	low	low	low	low
4	medium	low	medium	low	low	low	high	low	low	low	low
5	low	low	medium	low	low	low	high	low	low	low	low

The fact that Credibility of origin condition is not clearly described in official legal documents, is reflected in the risk no. 7. All examined entities are not 100% sure whether they will be challenged during the regulatory investigation how they meet this condition and if their understanding and their procedures would be considered by an investigation authority as sufficient. Also, fact that accounting is performed at HQ by a human who read the digital documents decrease risk evaluation of importing documents in risk no. 10 an 11 to low. Further research is needed to evaluate the risk when automated software-based no-human accounting solutions will be allowed to be implemented.

4 Conclusion

Digitalization of documents is the trend which every company would have to once implement. Companies which have already started to process digital documents, face commencing issues and problems that they must fine-tune and overcome. As the legislation in

Slovakia allowing digitalization is new, there is lack of instructions, court sentences, best-practices, and officially accepted procedures. Each entity is on its own; hoping they perform digitalization according to the requirements of the law.

As shown in this minor research, operational risks of processing documents form the point they were obtained to the point they are imported into software are well mitigated eighter by double check of an accountant who accounts or by simply best practices. Once, accounting will be performed solely by an automatic software-based solution, not by human accountants, the new even stronger process of risk mitigation must be implemented. Further R&D is needed to optimise and standardise digital documents among companies. There is also lack of legal explanations and guidance what increase legal risk of digitalization of accounting documents in Slovakia. There is also lack of unified harmonisation of accounting digitalisation among the international markets.

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Assessment of the Herd Effect Behaviour of Institutional Investors in China

Xu Du[1], Martina Novotná[2]

Abstract

The herd effect refers to the irrational behaviour of investors imitating the decisions of others in financial markets. When institutional investors have herd behaviour, the massive investment funds they hold may overflow to one end of the transaction, resulting in an imbalance in stock trading and aggravating the stock market's volatility. Although it can be assumed that herding does not occur in institutional investors' decisions, it is nevertheless appropriate to examine their behaviour in selected, especially emerging markets. Thus, the aim of this paper is to investigate whether there is a herd effect among institutional investors in the Chinese market. The main contribution of this paper is the evidence that herd behaviour does not occur in this market during the selected period. Therefore it can be said that despite certain obstacles in the Chinese capital market, institutional investors do not disturb its stability in this regard.

Keywords

Herd effect, institutional investor, model, linear regression analysis, stock market

JEL Classification: G14, G23, G40

1. Introduction

In the economic field, the original definition of herd effect emphasized investors' abandonment of personal information and judgments. Keynes (1936) took the lead in discussing the herd effect, using the "beauty pageant" as an example to illustrate the existence of the herd effect, and gave its original definition as follows. Because individual decision-makers have private information and other people's decision-making information, imitating or following other people's decisions and giving up their personal information is the herd effect. Scharfstein and Stein (1990) believe that the specific manifestation of the herd effect is that people no longer believe in their own investment choices, abandon their personal opinions and decisions already made, and blindly follow the majority's views. Cote and Sanders (1997) believe that when investors gradually lose their self-judgment and begin to cater to the opinions and ideas of the public, herd behaviour occurs.

With the development of research in finance, the definition of herd effect not only emphasizes the blind obedience of investors but also pays attention to the consistency of transaction time. Banerjee (1992) defined herd behaviour as a model of many people's investment behaviour based on comparing and analyzing the results of individual and other people's decisions, ignoring the decision-making ability based on personal information self-judgment. Lakonishok, Shleifer, and Vishny (1992) discussed the herd effect in the stock market more specifically and believed that the herd effect is that most investors make similar stock trading operations in the same amount of time (mainly reflected in the consistency of trading directions). They especially advocated that the herd effect of the stock market has the same time. Nofsinger and Sias (1999) also believe that the performance of the herd effect in the

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investment market is that a large number of investors buy or sell in the same direction simultaneously, with strong consistency in decision-making.

Bikhchandani and Sharma (2000) summarized and elaborated on the definition of the herd effect. Taking into account the loss of self-judgment, the imitation of transactions and the unification of transaction behaviours in time, they believe that in the investment field, investors generally rely on the information elements they have learned and their efforts to analyze to form a complete investment judgment. However, suppose the investor knows that other people have decided not to invest in the opposite direction of his own decision. In that case, he will adjust his decision, follow the majority's judgment, and not participate in the investment. Similarly, when he decides not to participate in investment according to information, if he knows that other investors have made investment decisions, he will also change his judgment to follow the venture investment and buy or sell the same securities simultaneously.

The herd effect in the securities market often has a variety of formation mechanisms, including herd theory based on group psychology (Asch, 1952). More recent views are based on the manager compensation theory (Roll, 1992; Brenan, 1993), incomplete information (Avery and Zemsky, 1998; Bikhchandani, Hirshleifer and Welch, 1998) and reputation-based herd theory (Scharfstein and Stein, 1990; Graham,1999).

Institutional investors are important participants in capital market transactions and the backbone of capital market development. Due to a large amount of trading capital and the value and long-term investment concept, the healthy development of institutional investors is crucial to stabilizing the securities market and guiding small and medium investors to form a more rational investment concept. Therefore, studying the herd behaviour of institutional investors helps better understand the investment behaviour and their investment decisions. At the same time, China's financial market belongs to the financial market of emerging countries. So then, research on the herd behaviour of Chinese institutional investors will also serve as a good model for researchers to investigate the investment behaviour of institutional investors in other emerging countries' financial markets.

With the vigorous development of China's stock market, China's institutional investors have gradually grown. The institutional investors in China can be traced back to the Shenzhen Special Economic Zone Securities Company, established in 1987, the first professional securities company in China. The Shanghai Stock Exchange and Shenzhen Stock Exchange, established in 1990 and 1991, respectively, marked the formation of China's securities market. Since then, many securities companies have been found, and other institutions have also invested in China's stock market. Among them, securities investment funds are the largest and most influential institutional investors in the Chinese stock market and are the most important institutional investors in the Chinese stock market. Although the Chinese stock market has been operating for many years, it can be assumed that market efficiency (e.g. lack of information) may be impaired due to regulation, various restrictions and government interventions. For this reason, the aim of this paper is to assess if the herding effect is present in the investment decisions of institutional investors who have a large impact on the capital markets.

The structure of the paper is as follows. First, the approaches and used methods are described in section two. Then, the empirical analysis and main findings are presented in the third section. Finally, the overall results and recommendations are summarized in the conclusion.

2. Description of the Herd Effect Model

The study of the herding effect has recently been the focus of investor trading behaviour analysis. One of the approaches used to assess the herd effect is models based on investors' transaction aggregation, for example, the LSV model and the degree of dispersion of stock returns measured by CSSD and CSAD models. In this paper, herd behaviour is assessed by the extended CSAD model focused on the behaviour of institutional investors.

Research in recent years suggests a positive correlation between institutional investors' shareholding changes and the current stock returns. For example, empirical studies by Wermers (1999) and Bennett, Sias and Starks (2003) on the US market show that quarterly changes in institutional investors' positions correlate significantly positively with quarterly stock returns. Furthermore, the relevant studies on the Chinese market by Yu, Li, Wang (2009) and Chen, Zhang, and Liu (2010) prove a strong positive correlation between the daily position changes of Chinese institutional investors and stock returns.

Based on the above research, Mei and Hu (2014) extended the traditional CSAD model theoretically and methodically from the perspective of the institutional position change. Drawing on the definition of CSAD by Chang, Cheng and Khorana (2000), they proposed the cross-sectional absolute deviation (IPCSAD) of institutional investors' position changes. The model measures whether institutional investors in the market have a herd effect through the degree of deviation between the position changes of institutional investors in individual stocks and the position changes of institutional investors in the whole market. Then,

$$IPCSAD_t = \frac{1}{N}\sum_{i=1}^{N}\left|IP_{i,t} - IP_{m,t}\right|, \tag{1}$$

where N is the number of stocks in the stock market, $IP_{i,t}$ is the change in the position of institutional investors of stock i in the period t, and $IP_{m,t}$ is the change in the position of total institutional investors in the whole market in period t. $IPCSAD_t$ represents the cross-sectional absolute deviation of institutional investors' position changes in period t.

Next, based on the research by Mei and Hu (2014), the CAPM model is combined with (1), assuming a positive correlation exists between changes in institutional investors' positions and the current returns of stocks. Therefore, we establish two regression models,

$$R_{i,t} = \beta_{i,0} + \beta_{i,1}IP_{i,t} + \sum_{i=2}^{S}\beta_{i,t}^{j}K_{i,t}^{j} + \varepsilon_{i,t}, \tag{2}$$

$$R_{m,t} = \beta_{m,0} + \beta_{m,1}IP_{m,t} + \sum_{i=2}^{S}\beta_{m,t}^{j}K_{m,t}^{j} + \varepsilon_{m,t}. \tag{3}$$

$IP_{i,t}$ is the change in the position of institutional investors of stock i and $IP_{m,t}$ is the change in the position of total institutional investors in the whole market in period t. $K_{i,t}^{j}$ and $K_{m,t}^{j}$, $j = 2,\ldots,S$, represent the control variables, respectively. We assume that the $\varepsilon_{i,t}$ and $\varepsilon_{m,t}$ are both equal to zero.

Next, equations (2) and (3) are used in the CAPM model expressed as,

$$E_t(R_{i,t}) - E_t(R_{m,t}) = (\beta_i - 1)\left[E_t(R_{m,t}) - r_f\right]. \tag{4}$$

After further adjustments and equation substitutions, we finally get the first and second-order partial derivatives of $E(IP_{m,t})$ for $E(IPCSAD_t)$:

$$\frac{\partial E(IPCSAD_t)}{\partial_t E(R_{m,t})} = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{\beta_{m,1}}{\beta_{i,1}}\beta_i - 1\right| > 0, \tag{5}$$

$$\frac{\partial^2 E(IPCSAD_t)}{\partial E(IP_{m,t})^2} = 0. \tag{6}$$

Based on (5) and (6), there is a linearly increasing relationship between the cross-sectional absolute deviation of institutional position change $IPCSAD_t$ and the total position change of institutional investors $IP_{m,t}$. However, if there is a herd effect in the market, at this time, the views of most institutional investors will tend to the market public opinion, and there will be investment behaviours of institutional investors buying or selling at the same time. The specific performance is the consistency of position changes. Then, the linear relationship between $IPCSAD_t$ and $IP_{m,t}$ no longer holds, but there is a nonlinear relationship.

However, the assumptions of the CAPM model cannot be fully satisfied because the development of the Chinese market is still imperfect. Therefore, the explanatory power of the single-variable linear regression equation is not enough to meet the needs of the Chinese stock market. On this basis, we need to add a quadratic coefficient to the newly established regression model, which can give stronger explanatory power to the final calculation result.

Therefore, according to the above analysis, we can establish the regression model as follows:

$$IPCSAD_t = \beta_0 + \beta_1 \left| IP_{m,t} \right| + \beta_2 IP_{m,t}^2 + \varepsilon_t, \tag{7}$$

where β_1 and β_2 are estimated coefficients and β_0 is the constant term. If there is a herd behaviour by institutional investors to centrally adjust their positions and exchange shares, then $IPCSAD_t$ will decrease with the increase of $IP_{m,t}$. At the same time, when we analyze the possible calculation results of the regression equation, we can find that if the value of β_1 and β_2 is negative, the $IPCSAD_t$ will likely decline with the transition of $IP_{m,t}$ to the maximum or minimum value. Since β_2 is a quadratic term coefficient, it can detect the occurrence of the above transition more sensitively than the first-order term coefficient β_1. Therefore, when the regression coefficient β_2 in equation (7) is meaningfully negative, it can be considered that institutional investors have herd behaviour.

The above-described method and the IPCSAD model is an extension of the CSAD model, which retains the advantages of the CSAD model. These include that data is relatively easy to collect, considering the trading volume of stocks and the ability to detect subtle herd effects. At the same time, the IPCSAD model also makes up for the defect that the CSAD model cannot simply measure the herd effect of institutional investors, which lays a good foundation for this thesis to study the herd effect of institutional investors.

3. Empirical Assessment of the Herd Behaviour

In this paper, our research goal is to explore whether there is herd behaviour among institutional investors in the Chinese market, so we select data from stocks listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange. The time interval of the data selected in this study is from January 1, 2019, to September 30, 2021, a total of 669 trading days. The data comprises the proportion of the net inflow of institutional investors' funds in the selected time interval for the selected stocks, A-shares, listed on the exchanges.

Firstly, the variables $IPCSAD_t$ and $IP_{m,t}$ are collected and prepared for data. Next, based on equations (1), (4) and (7), the empirical study on the herd effect is conducted in the following section. The independent and dependent variables used in the empirical analysis are summarized in Table 1. The data used in this paper are extracted from the Wind database and empirically analyzed by Stata 15.1 software. Since China's securities market is mainly divided into Shanghai Stock Exchange and Shenzhen Stock Exchange, the regression analysis is performed on the stocks of companies listed on both stock exchanges.

Table 1: Used variables

Symbol	Meaning	Variable
ipcsadt	Original $IPCSAD_t$	Y_t
absipmt	Original $\lvert IP_{m,t} \rvert$	X_{1_t}
ipmt2	Original $IP^2_{m,t}$	X_{2_t}
ny	Adjusted $IPCSAD_t$ Model$_{SHA(2)}$ Model$_{SZE(2)}$	 $Y^* = Y_t - 0.7418637Y_{t-1}$ $Y^* = Y_t - 0.7973007Y_{t-1}$
nx1	Adjusted $\lvert IP_{m,t} \rvert$ Model$_{SHA(2)}$ Model$_{SZE(2)}$	 $X_1^* = X_{1_t} - 0.7418637X_{1_{t-1}}$ $X_1^* = X_{1_t} - 0.7973007X_{1_{t-1}}$
nx2	Adjusted $IP^2_{m,t}$ Model$_{SHA(2)}$ Model$_{SZE(2)}$	 $X_2^* = X_{2_t} - 0.7418637X_{2_{t-1}}$ $X_2^* = X_{2_t} - 0.7973007X_{2_{t-1}}$

3.1 Estimation of Regression Models

The linear regression analysis is a widely used statistical method, so the theory behind all the tests mentioned below in the text is not described in this paper. However, the following authors, for example, can be recommended for a detailed explanation of the used procedures: Kennedy (2008), Gujarati and Porter (2009), Harrell (2010), Gujarati (2011), Hill, Griffiths and Lim (2012) or Chen (2014).

The procedure of model estimation is as follows. Initially, the stationarity tests on the selected variables are performed using the Dickey-Fuller test (DF). Then, the regression model assumptions are checked for autocorrelation, homoscedasticity and multicollinearity.

The presence of autocorrelation is assessed by Durbin-Watson test (DW). Next, the Cochrane-Orcutt method is used to adjust the regression model if autocorrelation is present. Next, the White test is applied to test for heteroscedasticity, and the weighted least squares method is used to adjust and remove it if it is present in the model. Finally, multicollinearity is tested by the Variance Inflation Factors method (VIF). Subsequently, model specification is assessed by Ramsey's RESET test and the normality of residuals by the graphical analysis and Jarque-Bera (JB) test. In addition, the goodness-of-fit is evaluated by the coefficient of determination R^2.

The regression models are firstly estimated based on the original variables Y_t, X_{1_t} and X_{2_t}, denoted as Model$_{SHA(1)}$ and Model$_{SZE(1)}$, where SHA refers to the Shanghai Stock Exchange and SZE to the Shenzhen Stock Exchange. Then, the Cochrane-Orcutt procedure is used due to a strong autocorrelation in the models with original variables. Thus, the autocorrelation is removed (the new variables are shown in Table 1). Finally, the models, symbolized as Model$_{SHA(2)}$ and Model$_{SZE(2)}$, include new adjusted variables Y^*, X_1^* and X_2^*.

In addition, since there was a heteroscedasticity problem in the Shenzhen Stock Exchange regression model with adjusted variables, these variables were further modified. Therefore, nx2 was differentially transformed, and a new variable was used in the final model.

After all modifications, the models were tested for heteroskedasticity and multicollinearity. Based on the used tests, they are not present in the models. Finally, the estimated coefficients of four regression models with original and adjusted variables are summarized in Table 2.

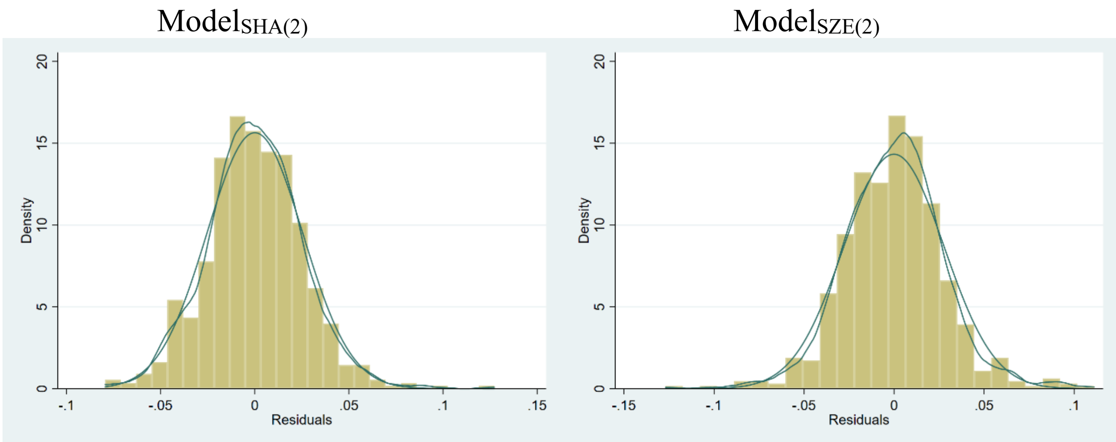
Table 2: Estimated coefficients of regression models

	$Model_{SHA(1)}$	$Model_{SZE(1)}$	$Model_{SHA(2)}$	$Model_{SZE(2)}$
β_0	0.1431*	0.1871*	0.0397*	0.0410*
β_1	0.8401*	0.6760*	0.5399*	0.5377*
β_2	2.8282*	0.3880	2.4150*	0.1480*
R^2	0.4157	0.5183	0.4871	0.7166
Adj. R^2	0.4140	0.5190	0.4856	0.7157

*significant at 0.05 level

According to the Ramsey-RESET test, all models are considered as correctly specified. However, the p-value of JB test suggests that residuals in the final models are not normally distributed, although the graphical analysis of residuals is very close to normal. However, because residuals are very close to the normal distribution based on Figure 1, the residuals are considered to be roughly normally distributed, and models will be further used for interpretation.

Figure 1: Distribution of reziduals



In summary, we conclude that $Model_{SHA(2)}$ and $Model_{Sze(2)}$ are statistically better than the models with original variables. Thus, the coefficients in their regression equations are statistically more explanatory.

For example, the final regression model of the Shangai Stock Exchange can be expressed as follows,

$$Y^* = 0.0397 + 0.5399X_1^* + 2.4150X_2^* + u_t. \quad (8)$$

From equation (8), we can see that the value of β_2 is 2.4150, which is a positive number indicating that there is no herd effect for institutional investors in the Shanghai market.

Analogically, the final model for Shenzhen Stock Exchange can be written as

$$Y^* = 0.0410 + 0.5377X_1^* + 0.1480X_2^* + u_t. \quad (9)$$

Similarly to the Shanghai market, the results suggest there is no herd effect of institutional investors in the Shenzhen Stock Exchange based on the positive value $\beta_2 = 0.1480$.

3.2 Main Findings and Discussion

The coefficients β_1 for $IP_{m,t}$ and β_2 for $IP^2_{m,t}$ are positive based on estimated regression models for both Shanghai and Shenzen Stock Exchange. Thus, according to equation (7), the results indicate an increasing relationship between $IPCSAD_t$, $IP_{m,t}$ and $IP^2_{m,t}$ at the 0.05 significance level. In other words, when the $IP_{m,t}$ and $IP^2_{m,t}$ increase, the $IPCSAD_t$ rises as well.

Through the above analysis, we provide evidence that there is no herd effect among Chinese institutional investors in both the Shanghai and Shenzhen securities markets. The possible reason for this phenomenon might be that as China's securities market continues to mature and China's financial regulators also improve the behavioural norms for institutional investors. Therefore, the trading behaviour of institutional investors tends to be more standardized and rational in the case of strict supervision and the gradual maturity of the market.

On the other hand, despite the COVID-19 pandemic during the selected time, China's stock market has generally been stable. The absence of extreme ups and downs in the stock market provides an appropriate environment for institutional investors to trade rationally. It is worth mentioning that Chinese institutional investors, as professional asset managers, have very professional trading knowledge in their minds, which makes it difficult for them to make irrational herd trading behaviours when the market is stable. At the same time, the very large scale of assets in their hands makes it difficult for them to buy and sell simultaneously because if a large number of institutional investors in the market conduct unilateral transactions, the market will inevitably fluctuate violently. However, the steady trend of the Chinese market during this period can also prove from another perspective that institutional investors do not have herd behaviour.

At the same time, we reflect on the research and think about possible ways to extend further research. In our work, we have only analyzed two selected markets as a whole and have not explored them in more detail. Although from the perspective of the market as a whole, institutional investors do not have herd behaviour in the market, we have no way of knowing whether institutional investors have herd behaviour in each market segment.

In subsequent research, we can segment the market by industry and explore whether institutional investors have a herd effect in each sector. By dividing the market, we can more accurately study the existence of the herd effect of institutional investors and then explore their investment preferences.

The main findings of this study are consistent with recent research. In this paper, the period of the data for our empirical analysis is from January 1, 2019, to September 30, 2021. Compared to the research by Mei and Hu (2014), they selected the period from April 16, 2010, to September 28, 2012. The evidence ultimately points to the conclusion that in the context of the herding effect, the behaviour of institutional investors in the Chinese stock market has not changed over time, and they do not have herding behaviour in their transactions.

4. Conclusion

Institutional investors are the main participants in the capital market and the backbone of promoting the long-term healthy development of the capital market. They play an important role in stabilizing the capital market, guiding small and medium investors to form correct investment ideas, and improving the governance level of listed companies. Institutional investors in China have developed rapidly in recent years, but they still have shortcomings such as unbalanced structure and irrational investment behaviour. The presence of the herd effect is a typical representative of irrational behaviour.

Herd behaviour is a kind of imitation behaviour, which can be seen as investors will invest according to the previous participants' behaviour. They make financial assets trade in the same direction by imitating other people's investments. In behavioural finance, investors lack timely access to adequate information when market efficiency and investor rationality assumptions do not exist. As a result, they cannot scientifically and accurately analyze information to make decisions. In the financial market, the herd behaviour of institutional investors is mainly manifested in the consistency of transaction behaviour and transaction time. At the same time, institutional investors may concentrate their capital in convergent transactions in pursuit of higher yields, increasing volatility in financial markets.

Based on the status quo of the rapid development of Chinese institutional investors, this paper conducts research on the existence of the herd effect of Chinese institutional investors. This study provides a sample for researchers to investigate the investment behaviour of institutional investors in financial markets in other emerging countries. It can also provide financial market regulators with new ideas for regulating institutional investors. In this way, institutional investors' capital can more effectively help the development of financial markets.

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