“Integrated performance measurement system for Slovak heating industry: A balanced scorecard approach”

AUTHORS	Jarmila Horvathova Martina Mokrisova

ARTICLE INFO	Jarmila Horvathova and Martina Mokrisova (2023). Integrated performance measurement system for Slovak heating industry: A balanced scorecard approach. *Problems and Perspectives in Management*, *21*(3), 393-407. doi:10.21511/ppm.21(3).2023.32
DOI	http://dx.doi.org/10.21511/ppm.21(3).2023.32
RELEASED ON	Monday, 28 August 2023
RECEIVED ON	Thursday, 11 May 2023
ACCEPTED ON	Monday, 10 July 2023

JOURNAL	"Problems and Perspectives in Management"
ISSN PRINT	1727-7051
ISSN ONLINE	1810-5467
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
95	1	5

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine

www.businessperspectives.org

Jarmila Horváthová (Slovakia), **Martina Mokrišová** (Slovakia)

INTEGRATED PERFORMANCE MEASUREMENT SYSTEM FOR SLOVAK HEATING INDUSTRY: A BALANCED SCORECARD APPROACH

Abstract

The prerequisite for businesses' success, competitiveness, and non-bankruptcy is their performance. An effective performance measurement system is a suitable tool for measuring and improving business performance. The development in performance measures moved from financial measures focused on company profitability to measurement systems combining different methods, approaches, and tools. The paper aims to identify key performance indicators for Slovak heating companies based on the developed integrated performance measurement system. The analysis sampled 292 Slovak companies within SK NACE 35 (heating industry). The performance measurement system was built on balanced scorecard principles, while the least absolute shrinkage and selection operator (Lasso regression) method was used to select financial indicators. Based on the combination of the above methods, a performance measurement system framework for the analyzed sample of businesses was created. The results show that when managing performance, the analyzed businesses should focus on the following financial performance indicators: Receivables turnover ratio, Return on equity, Return on costs, Total debt to total assets, Material intensity, Labor to revenue ratio, Netto cash flow to assets, Net working capital to total assets, and Short-term liabilities to assets. When building performance measurement system based on balanced scorecard principles, financial indicators were supplemented by non-financial ones. In addition to the original balanced scorecard principles, the performance measurement system was extended by environmental constituents. Also, the paper's deliverable combines Lasso regression and balanced scorecard principles in order to select key performance indices.

Keywords balanced scorecard, economic value added, indicator, Lasso regression, performance measurement system

JEL Classification M11, M21, D24, D20

Received on: 11th of May, 2023
Accepted on: 10th of July, 2023
Published on: 28th of August, 2023

Jarmila Horváthová, Doc. Ing. CSc., Associate Professor, Faculty of Management and Business, University of Prešov, Slovakia.

Martina Mokrišová, Doc. Ing. PhD., Associate Professor, Faculty of Management and Business, University of Prešov, Slovakia. (Corresponding author)

Conflict of interest statement:
Author(s) reported no conflict of interest

INTRODUCTION

Performance is critical in the business's life because if business is inefficient, it is not competitive and may go bankrupt. In order to effectively measure performance, companies should have a balanced system of performance measures. These measures should include the most relevant performance indicators (Oukhay & Romdhane, 2022). Several methods can be used to create performance measures, while a balanced scorecard is one of the essential approaches. However, nowadays, in creating a performance measurement system, various methods are used, including the application of mathematical and statistical ones (Valmohammadi & Servati, 2011).

The main issue is to create an effective system for measuring the business performance, which integrates key performance indicators from all functional business areas. Applying a balanced scorecard with a suitable mathematical and statistical method for selecting performance indicators is the best approach.

1. LITERATURE REVIEW AND HYPOTHESES

Business performance is a term widely used in the daily life of businesses. In today's dynamic and digital era, maintaining the position of companies in the market, their financial results, and performance is demanding and requires a lot of activities and subsequent measurements. Suppose companies want to achieve a significant position in the market and maintain a competitive advantage. In that case, they need a balanced performance measurement system to ensure the controlled use of available resources to fulfill their goals and strategy. As a result, businesses became interested in developing an effective performance measurement system (Keong Choong, 2013; Vilanova et al., 2015). This topic became an important challenge for scientists and practitioners in the late 1980s, thanks to Johnson and Kaplan (1987). Neely (1999) stated that between 1994 and 1996, more than 3,600 articles were published on business performance measurement, thus giving rise to the phrase "performance measurement revolution" (Gutierrez et al., 2015). Also, Keong Choong (2014) found that recently many journals have been devoted to the issue of performance measurement.

Performance measurement can be defined as measuring performance using performance indicators. According to Neely et al. (1995), performance measures assess the effectiveness and efficiency of past actions. A quality performance measurement system is required to guide this process, namely the software, databases, and procedures necessary to ensure that performance measurement is consistent and complete. In this context, it is also possible to define management performance, according to Bititci et al. (1997), as the process by which an organization integrates its performance into its corporate and functional strategies and objectives.

Franco-Santos et al. (2007) noted two basic characteristics of the performance measurement system. A system of performance indicators is confirmed by 53% of interviewed experts; goal setting is confirmed by 35% of studies researching performance measurement system. Given the research and opinions on the issue, there is a consensus of opinions in implementing performance measurement tasks. 59% of studies consider the implementation and execution of the strategy to be a vital characteristic of the performance measurement system; 41% suggest "focusing on alignment," "internal communication," and "measuring or evaluating performance," and 35% report "monitoring progress" as essential activities in this context. This process is "providing information to managers." Up to 53% of articles in the given area confirmed this system's characteristics.

Bourne et al. (2000) and Nudurupati et al. (2011) noted that in creating business performance measurement systems, classical approaches were mainly applied, which were based on the use of data from accounting systems. According to Neely et al. (2003), performance measurement focused primarily on financial measures. There are also new approaches to measuring financial performance and methods such as activity-based costing, free cash flow, economic value added, or shareholder value analysis.

As stated by Rosová and Balog (2012) and Horváthová and Mokrišová (2021), the system of measuring business performance began to be supplemented with non-financial business performance indicators, so the performance measurement system represented a multidimensional platform. These studies were based on Drucker's (1954) proposal to develop a balanced performance measurement system (Neely, 2005). However, this multidimensionality can cause various problems. These are, for example, conflicts between performance rates, a suitable balance of internal and external actions, and a link between measures and strategies. One way to overcome the inherent complexity of designing a performance measurement system is to use structured design methodologies (Neely et al., 1996).

Despite some shortcomings, research on performance measurement system has continued, and a large number of frameworks have emerged (Horváthová & Mokrišová, 2021). Vochozka et al. (2017) and Vilanova et al. (2015) include benchmarking, balanced scorecard, business excellence, knowledge management, management quality system, and SWOT analysis. Other important frameworks for measuring performance are the performance pyramid (Lynch & Cross, 1991), result-determinant framework (Brignall et al., 1991),

http://dx.doi.org/10.21511/ppm.21(3).2023.32

and performance measurement matrix (Keegan et al., 1989). These frameworks have integrated traditional financial performance indicators with non-financial, external, and forward-looking measures (De Toni & Tonchia, 2001; Gosselin, 2005; Bititci et al., 2012; Silvi et al., 2015).

A balanced scorecard is considered one of the first performance frameworks, which were complex and supplemented financial indicators with non-financial ones (Neely et al., 2003). It was developed by American consultants Kaplan and Norton (1992). Since then, it has gained popularity mainly due to its complexity and clarity at all levels of management (Dumitrescu & Fuciu, 2009). So far, three generations of balanced scorecards have taken turns since 1992 (Madsen & Stenheim, 2015).

A balanced scorecard represents a significant contribution in improving the company's performance. When using this method, companies must determine the mission, vision, and strategy (Kaplan & Norton, 1996; Mokrišová & Horváthová, 2021). The original performance management system introduced by Kaplan and Norton (1996) consisted of a financial perspective, customer perspective, perspective of internal processes, and learning and growth perspective, which are still used today. In addition to these traditional perspectives, new ones are emerging in line with the development of the 4th generation of a balanced scorecard (Ali, 2019). In terms of ensuring sustainable development, it is mainly an environmental, sustainability, or social responsibility perspective. Bititci et al. (2012) also mentioned the possibility of measuring performance outside the organization among business partners.

Despite the fact that the use of only financial indicators in measuring the performance of companies is often criticized, the financial perspective remains the most significant. This perspective measures the satisfaction of owners. The economic value added (EVA) is the most suitable indicator that can be used to measure satisfaction.

In addition to the EVA indicator, the indicators that will support the growth of the company's performance shall be chosen. These indicators include investment return rate, profitability, shareholder value, income growth, and unit costs. Unit costs, in particular, are among the delayed measures and indicate the organization's strategic success (Fooladvand et al., 2015). According to Sainaghi et al. (2013), the financial perspective aims to reach profitability. In this perspective, there are goals such as the value expressed by the indicators of economic value added, return on equity, return on assets, assets turnover, liquidity of the organization, or other financial goals (Horváthová et al., 2013). When designing individual financial objectives, it is also necessary to consider the current stage of the life cycle of the company (Kaplan & Norton, 1992; Mooraj et al., 1999; Horváthová & Suhányiová, 2012).

Concerning the customer perspective, the company's values, goals, and measures are customer-oriented. These include values such as delivery, quality, performance, and type of communication (Fooladvand et al., 2015). According to Kaplan and Norton (1996) and Lesáková (2004), from a customer perspective, it is possible to use targets and measures focused on market share, which can be expressed as the number of customers, sales volume or number of products sold, new customers or new orders in absolute or relative terms, customer loyalty, customer satisfaction, or profitability.

The third balanced scorecard perspective is the internal business process perspective, which can include both short-term and long-term objectives (Kaplan & Norton, 1996). The critical processes that are effective in relation to the strategy are identified, and suitable indices for measuring process performance are determined (Fooladvand et al., 2015). The internal operating processes in businesses have to follow a plan of operating strategies, while businesses should do their best to achieve the expectations of their customers and shareholders (Wu et al., 2011). In line with it, the whole process starts with understanding customer requirements, innovation process, operation process, and after-sales service. Finally, it achieves customer requirements to establish evaluation indexes through all of these (Wu et al., 2011, p. 39). According to Pandey (2005), it is the most critical perspective of the organization's success, as the internal business processes ensure the highest quality of products and services.

Concerning the perspective of growth and education, these main areas of learning and growth are defined: employee skills, information system skills, motivation, delegation of authority, and commitment. Most companies use employee goals to measure employee ability, which is taken from three groups of input measures: employee satisfaction, employee fluctuation, and employee productivity (Kaplan & Norton, 1996). From this perspective, it is possible to identify intangible and tangible backgrounds for ensuring strategic success. The strategic goals of this perspective are selected with regard to human capital, staff abilities, knowledge, technology, and organizational culture.

In recent years, in line with environmental concerns, there has been a trend of incorporating environmental and social indicators into the balanced scorecard (Krivokapić & Jovanović, 2009). According to Epstein (1996) and Figge et al. (2002), it is possible to incorporate these indicators in three ways: to incorporate them into existing standard perspectives, to create a new perspective, or to create a new specific environmental/social scorecard. Figge et al. (2002) and Krstić et al. (2015) do not focus on environmental aspects, but they prefer the sustainable balanced scorecard concept (sustainability balanced scorecard). However, it seems that there is no fundamental difference between these approaches. According to Krivokapić and Jovanović (2009), the sustainable balanced scorecard approach is predominantly oriented to formulating environmental strategies and social aspects of a business. Hsu and Liu (2010) researched balanced scorecard in more depth and formulated an environmental strategy based on a balanced scorecard. The output is an environmental strategy map.

The development of the balanced scorecard application also pointed to the fact that it is a method of implementation that helps to increase company performance (Kaplan & Norton, 2001; Azar & Safari, 2021; De Geuser et al., 2009; Farooq & Hussain, 2011; Das, 2019; Tuan, 2020).

Nowadays, the trend is to combine various performance measurement methods (Guru & Mahalik, 2019; Nguyen & Luu, 2021) and to create integrated (Bayaraa et al., 2020) or hybrid (Zare et al., 2019; *İç* & Yurdakul, 2021) models. Such a model with the application of balanced scorecards and mathematical and statistical methods was created by Valmohammadi and Servati (2011). The study applied correlation analysis, the Kruskal-Wallis test, and one sample z-test to select strategic objectives and measures. Khanmohammadi et al. (2022) combined balance scorecards with system-dynamics models – case-based reasoning method and adaptive neuro-fuzzy inference system model.

When creating effective performance management systems, the main issue is to select the most relevant performance indicators, often known as key performance indicators (KPI) (Oukhay & Romdhane, 2022). These indicators should be linked to the company's strategic objectives and key business processes (Strelnik et al., 2015). They should be monitored in an integrated way (da Silva & Borsato, 2017), while the interactions among them should be investigated and considered (Oukhay & Romdhane, 2022). Two basic ways of selecting key performance indicators are domain knowledge and data mining techniques (Zhou et al., 2015). Tian et al. (2015) and Kumar et al. (2019) confirmed that Lasso regression is one of the best data mining techniques for selecting indicators. Recently, data mining techniques have been used in various areas of business evaluation, not only when measuring the performance of businesses but also when predicting their bankruptcy. Their benefit is that they allow reducing a large number of indicators to a smaller number of key indicators for a given area of evaluation.

Therefore, the aim of the paper is to identify key performance indicators for Slovak heating companies based on the developed integrated performance measurement system. It is based on balanced scorecard principles and data mining techniques. The research question is: What financial indicators are the best measures and driving forces for increasing company performance? As a result, the study elaborates on the following hypotheses:

H1: ROA is a key performance indicator for the analyzed sample of heat management companies.

H2: Total debt to total assets is a key performance indicator for the analyzed sample of heat management companies.

http://dx.doi.org/10.21511/ppm.21(3).2023.32

2. METHODOLOGY

The analysis sampled 292 Slovak companies within SK NACE 35 – "Supply of electricity, gas, steam, and cold air" – also known as the heating industry. In addition to certain industrial production processes, this industry is critical from a social point of view to ensure basic needs for everyday life. Therefore, it plays a key role within Slovak industries, which has been confirmed in recent years. The analyzed businesses represent local heat supply systems, which show characteristics of network industries (AOSR, 2013). They have to pay significant attention to environmental protection and renewable energy sources. The performance of analyzed businesses was assessed using liquidity and profitability ratios, debt management and assets management ratios, and operational ratios. Input data from financial statements were obtained from Slovak analytical agency CRIF – Slovak Credit Bureau (CRIF, 2022). Indicators were calculated with the use of formulas listed in Table 1. From these indicators, key performance indicators were selected.

To calculate the performance of businesses, EVA indicator was applied. The study used the following formulas to calculate EVA equity and EVA entity (Table 2).

Table 1. Formulas for the indicator's calculation

Indicator	Abb.	Formula
Current ratio	CL	$short-term\ assets\ /\ short-term\ liabilities$
Quick ratio	QR	$(short-term\ receivables + financial\ assets)\ /\ short-term\ liabilities$
Net working capital	NWC	$short-term\ assets - short-term\ liabilities$
Average collection period	ACP	$short-term\ receivables\ /\ sales \times 360$
Inventory turnover	IT	$inventory\ /\ sales \times 360$
Creditors payment period	CPP	$short-term\ liabilities\ /\ sales \times 360$
Cash-to-cash	CTC	$ACP + IT - CPP$
Return on assets	ROA	$EBIT\ /\ assets \times 100$
Return on assets with EAT	ROA_{EAT}	$EAT\ /\ assets \times 100$
Return on equity	ROE	$EAT\ /\ equity \times 100$
Return on sales	ROS	$EAT\ /\ sales \times 100$
Return on costs	ROC	$EAT\ /\ costs \times 100$
Total assets turnover ratio	TATR	$sales\ /\ assets$
Receivables turnover ratio	RTR	$sales\ /\ short-term\ receivables$
Liabilities turnover ratio	LTR	$sales\ /\ short-term\ liabilities$
Total debt to total assets	TDTA	$debt\ /\ assets\ *100$
Equity ratio	ER	$equity\ /\ assets \times 100$
Debt to equity ratio	DER	$debt\ /\ equity$
Equity to debt ratio	EDR	$equity\ /\ debt$
Equity to fixed assets ratio	EFAR	$equity\ /\ fixed\ assets$
Equity and long-term liabilities to fixed assets ratio	ELFAR	$(equity + long-term\ liabilities)\ /\ fixed\ assets$
Interest coverage ratio	ICR	$EBIT\ /\ interest\ expense$
Debt-service coverage ratio	DSCR	$interest\ expense\ /\ EBIT$
Short-term liabilities to assets	SLA	$short-term\ liabilites\ /assets$
Long-term liabilities to assets	LLA	$long-term\ liabilities\ /assets$
Short-term assets to assets	SAA	$short-term\ assets\ /\ assets$
Costs ratio	CR	$costs\ /\ revenues$
Revenue to costs ratio	RCR	$revenues\ /\ costs$
Labor to revenue ratio	LR	$labor\ costs\ /\ revenues$
Revenue to labor ratio	RR	$revenues\ /\ labor\ costs$
Material intensity	MI	$material\ costs\ /\ revenues$
Net working capital to total assets	NWCA	$net\ working\ capital\ /\ assets$
Net working capital to current assets	NWCCA	$net\ working\ capital\ /\ current\ assets$
Netto cash flow to debt	NCFD	$netto\ cash\ flow\ /\ debt$
Netto cash flow to assets	NCFA	$netto\ cash\ flow\ /assets$

Table 2. Formulas for EVA indicator calculation

Source: Neumaierová and Neumaier (2002), Mařík and Maříková (2005).

Method of EVA calculation	Formula	Explanation of variables
EVA Equity	$EVA_{Equity} = (ROE - r_e) \cdot E$	ROE – Return on equity, r_e – Cost of equity, E – Equity
EVA Entity	$EVA_{Equity} = NOPAT - WACC \cdot NOA$	$NOPAT$ – Net operating profit after tax, $WACC$ – Weighted average costs of capital, NOA – Net operating assets

To select suitable drivers of business performance, Lasso regression was applied. This method was formulated by Robert Tibshirani in 1996 (Fonti & Belitser, 2017). It is used for attribute selection and regularization. It uses the regularization process, in which it penalizes the absolute values of regression coefficients and reduces the insignificant coefficients' values to zero (Vadovský et al., 2018).

For logistic regression, the penalized version of the log-likelihood function to be maximized takes the form (1) (Pereira et al., 2016; Hastie et al., 2009):

$$l_{\lambda}^{L}(\beta) = \sum_{i=1}^{n}\left[y_i x_i \beta - \log\left(1 + e^{x_i \beta}\right)\right] - \lambda \sum_{j=1}^{p}\left|\beta_j\right|, \quad (1)$$

where x_i is the i-row of the matrix of n observations with p predictors and a column of 1 to accommodate the intercept, β is the column vector of the regression coefficients and λ is a tuning parameter.

The level of the penalty is regulated by the size of the coefficient λ. The higher the value of the coefficient λ, the more regression coefficients acquire a zero value (Vadovský et al., 2018). The coefficient λ is usually determined by the minimum prediction error in cross-validation, denoted as $\lambda_{\min}$. It is also possible to use the error of one standard deviation λ_{1se} to select the coefficient λ (Fonti & Belitser, 2017).

The Lasso regression was used for variable selection and shrinkage by Pereira et al. (2016), Fonti and Belitser (2017), Vadovský et al. (2018), and Meng et al. (2018).

The most significant performance indicators selected by Lasso regression were used to create the financial perspective of performance measurement system based on balanced scorecard principles. Financial performance indicators were supplemented by non-financial ones arranged into customers, processes, learning and growth, and environmental perspective to create an integrated performance measurement system.

3. RESULTS AND DISCUSSION

The descriptive statistics of the financial indicators of heat management companies are listed in Table 3. In terms of liquidity, the average of CL achieved 1.417, which can be considered sufficient with regard to the given sector. However, the median of this indicator was significantly lower. The indicator NWCCA reached a negative value, which can be assessed negatively. Regarding assets management, the average CPP achieved a critical value of 711 days. Better was the median of this indicator, which achieved 226 days. However, to improve the performance of analyzed businesses and prevent their bankruptcy, the results of this indicator need to be improved. Another assets management indicator (which results need to be improved) is TATR. In terms of profitability, the mean of ROA is 4.5%, while its median is 4.4%. Better results were achieved in the case of ROE, with a mean of 15.4% and a median of 12.6%. In terms of debt management ratios, TDTA achieved similarly high values of average and median, confirmed by low values of average and median of ICR. In most of the analyzed companies, it is necessary to pay increased attention to the optimization of these indicators. Value of the indicator NCFD achieved on average 15%. Regarding operational ratios, the average is 1.005, while the median is slightly lower.

Table 4 shows the results of the EVA indicator. Due to the large number of companies, the results were divided into intervals for better presentation. EVA equity achieved positive value in 163 businesses, which means that their perfor-

http://dx.doi.org/10.21511/ppm.21(3).2023.32

Table 3. Descriptive statistics for the analyzed businesses

Indicator	Descriptive statistics				
	Average	Median	Minimum	Maximum	Standard deviation
CL	1.42	0.81	0.02	20.02	2.46
QR	1.35	0.73	0.02	19.10	2.44
NWC	–326,05	–104,88	–67,865,68	136,730,06	9,733,49
ACP	0.43	0.16	–0.08	21.73	1.44
IT	0.08	0.00	0.00	3.66	0.36
CPP	1.97	0.63	0.04	78.45	5.96
TATR	0.73	0.25	0.00	9.93	1.39
RTR	10.69	6.20	–12.42	334.34	21.90
LTR	2.60	1.60	0.01	25.81	3.55
ROA	0.05	0.04	–0.29	0.54	0.09
ROE	0.15	0.13	–16.18	9.10	1.40
ROS	–0.12	0.04	–41.53	4.94	2.57
ROC	0.07	0.04	–3.63	1.06	0.35
ER	0.16	0.15	–2.57	0.98	0.33
TDTA	0.84	0.86	0.02	3.57	0.33
EDR	0.67	0.17	–0.72	57.41	3.58
DER	0.84	0.86	0.02	3.57	0.33
ICR	2.53	1.85	–33.30	35.14	6.08
DSCR	–0.75	0.32	–372.77	35.47	22.02
EFAR	4.63	0.20	–3.86	1,155.16	67.60
ELFAR	6.24	0.96	–3.85	1,401.87	82.01
CR	1.01	0.96	–0.25	5.32	0.49
MI	0.27	0.09	0.00	1.26	0.28
LR	0.04	0.00	–0.00	0.43	0.06
RCR	1.08	1.05	–3.98	2.24	0.42
RR	2.54	1.00	–2,289.19	863.92	150.09
NWCCA	–1.62	–0.24	–50.56	0.95	5.56
NCFD	0.15	0.12	–0.27	1.45	0.17
NCFA	0.10	0.10	–0.17	0.72	0.10
ROA_{EAT}	0.01	0.02	–0.34	0.45	0.08
NWCA	–0.08	–0.03	–3.23	0.78	0.33
SAA	0.27	0.18	0.00	1.00	0.26
LLA	0.49	0.56	0.00	1.62	0.38
SLA	0.35	0.24	0.01	3.57	0.34

mance is good; the performance of the remaining 129 businesses is poor. A positive value of EVA entity achieved 217 businesses, while the performance of the remaining 75 businesses was poor. In both methods of calculating the EVA indicator, most companies placed in the interval (0.4).

The results presented in Table 4 indicate that there are more well-performing businesses than businesses with poor performance in the analyzed sample. When using the EVA entity indicator, the number of well-performing businesses was higher than some businesses with poor performance. It is given by the method of calculation and the fact that in the case of EVA entity, the result produced by the enterprise using mixed capital and the average price of mixed capital enter into the calculation. In the case of the capital structure of enterprises with a greater share of debt, it is more favorable than the equity price.

Lasso regression was used to select suitable financial performance drivers for performance measurement system (Table 5).

Table 4. Results of the EVA indicator

Value of the EVA indicator (in millions EUR)	EVA Equity – number of companies	EVA Entity – number of companies
(–50, –46)	1	0
(–46, –42)	0	1
(–42, –38)	0	0
(–38, –34)	0	0
(–34, –30)	0	0
(–30, –26)	0	0
(–26, –22)	1	0
(–22, –16)	1	0
(–16, –12)	0	0
(–12, –8)	1	1
(–8, –4)	1	1
(–4, 0)	124	72
(0, 4)	160	213
(4, 8)	0	1
(8, 12)	1	2
(12, 16)	2	1
Mean	–241,06	–22,14
Median	–11,465	48,579
Total	292	292

Table 5. Indicators selected with the use of Lasso regression

Variables	Logistic regression. Model Lambda = 0.000044, %Dev = 0.998250
	Estimates
RTR	–0.0712519977
ROE	–0.262969586
ROC	8.51164054
TDTA	–165.473394
MI	2.10401833
LR	17.6595503
NCFA	10.2814385
NWCA	0.616725334
SLA	–0.976165851

The results of the Lasso regression confirmed the significance of the following financial indicators as performance drivers: total debt to total assets, labor to revenue ratio, netto cash flow to assets, return on costs, material intensity, short-term liabilities to assets, net working capital to total assets, return on equity and receivables turnover ratio. These results confirm H2: total debt to total assets is a key performance indicator for the analyzed sample of heat management companies. On the other hand, the study rejects H1: ROA is not a key performance indicator for the analyzed sample of companies. Selected key financial performance indicators were used to create a financial perspective of a strategy management map (Figure 1). Indicators for other perspectives were designed based on the secondary information of the analyzed companies. A strategy management map represents a basis for creating a performance measurement system in analyzed businesses. It contains strategic objectives which can be monitored with the use of strategic measures.

The top goal of the strategy management map is "to increase the value of the company" measured by the EVA indicator. The results of this synthetic performance indicator are optimized by increasing or decreasing the values of financial and non-financial measures from individual perspectives. EVA indicator has been widely used by Debdas (2006), Tudose et al. (2021), and Geng et al. (2021). Verevka (2018) used this indicator from the financial perspective of a system of key performance indicators for the efficiency evaluation of high-tech enterprises. In addition to the original perspectives, the strategy management map also contains the environmental perspective.

http://dx.doi.org/10.21511/ppm.21(3).2023.32

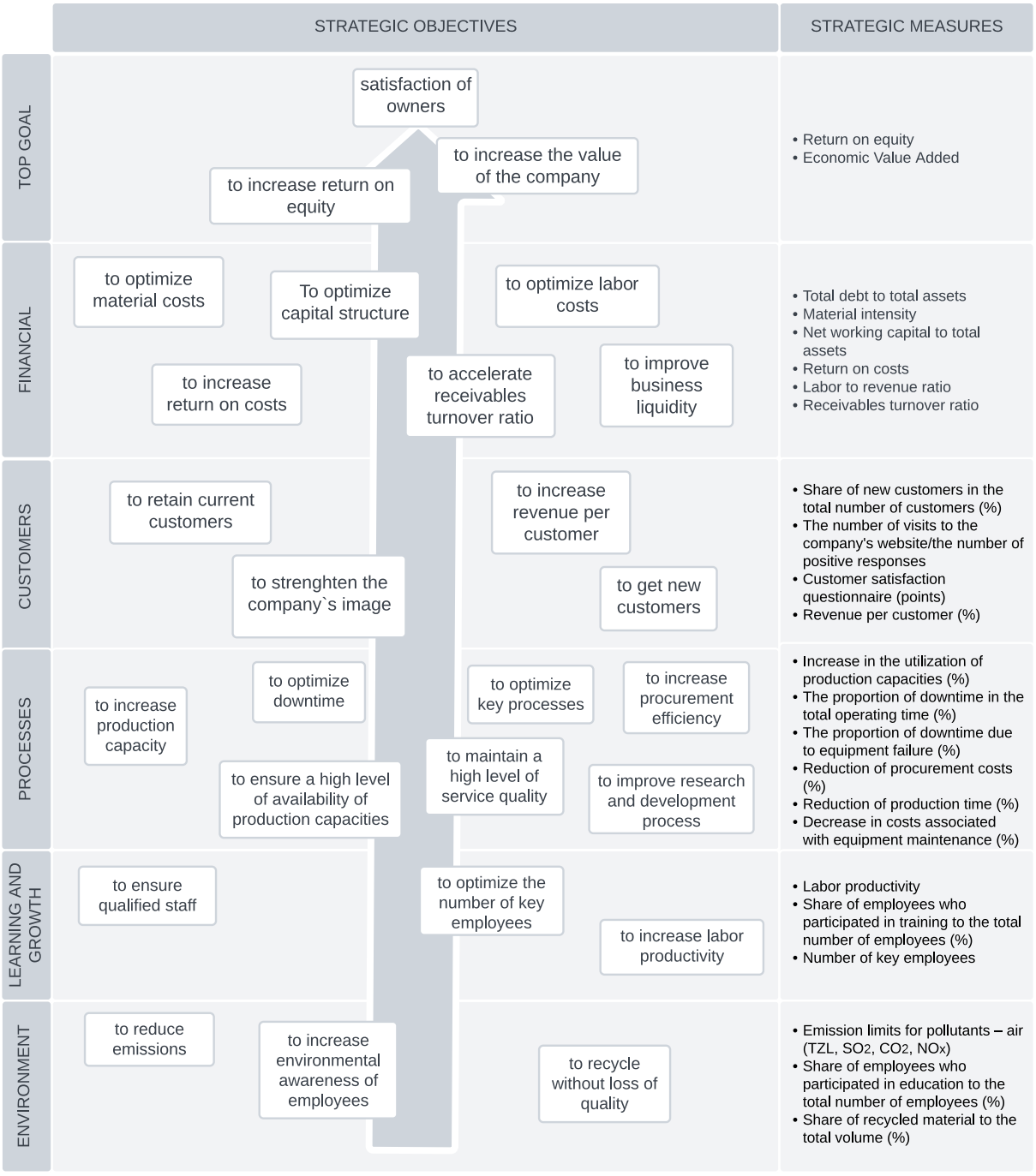

Figure 1. Strategy management map as a platform for building performance management system

The choice of a balanced scorecard as a platform for the creation of performance measurement system was confirmed by Kaplan and Norton (1996), Heinz (2001), Bourne et al. (2003), Robinson et al. (2005), Soderberg et al. (2011), Peng and Zhou (2011), Shutibhinyo (2012), Karpagam and Suganthi (2013), Behery et al. (2014), Barroso et al. (2016), Singh and Arora (2018), Lee et al. (2021), and Song (2022).

Lasso regression analysis was used to select critical financial performance indicators for performance management system. Rapach et al. (2013) and Cao et al. (2022) demonstrated that Lasso regression outperforms forward or backward stepwise regression. Paraschiv et al. (2021) found that input variables chosen by Lasso regression yield the best in-sample fit, out-of-sample performance, and stability.

This paper identified the following key financial performance indicators: total debt to total assets, labor to revenue ratio, netto cash flow to assets, return on costs, material intensity, short-term liabilities to assets, net working capital to total assets, return on equity, and receivables turnover ratio. Some of them were previously identified as key performance indicators. M. Hegazy and S. Hegazy (2012) proposed the following key performance indicators for the construction industry: current ratio, quick ratio, gearing, times interest, accounts receivable turnover, average collection period, inventory turnover, gross profit margin, profit margin, return on investment, and return on equity. Kucukaltan et al. (2016) applied balanced scorecard principles and the analytic network process method to identify performance indicators of logistics companies. The financial perspective of their model included cost, profitability, sales growth, and equity ratio. Mikušová and Janečková (2010) identified cash flow and liquidity as key financial performance indicators of small family firms operating in the wood-working industry. They pointed out that the development of liquidity is affected by indebtedness and profitability. Kraus and Lind (2010) and Nastasiea and Mironeasa (2016) included cash flow among crucial financial performance indicators.

Thus, this study concludes that some indicators are the same in the mentioned studies. However, some of them vary, which can be caused by various industries analyzed in the studies or different methods applied for indicators selection. In the future, other data mining techniques or mathematical and statistical methods can be used for indicator selection combined with balanced scorecard's principles.

CONCLUSION

The paper aimed to identify key performance indicators for Slovak heating companies using the integrated performance measurement system. Clearly, 74% of the companies from the given sample can be considered well-performing. These companies achieve a return on equity of 57% and current liquidity of 1.5. On the other hand, inefficient companies achieve a negative return on equity –30% and current liquidity of approximately 1.2.

In order to maintain and manage the performance of the analyzed sample of companies, it is necessary to build a balanced system of performance indicators. The top indicator is economic value added, a synthetic indicator whose value reflects the influence of all performance measurement system indicators. Despite criticism of the financial perspective, it plays the most crucial role in performance measurement systems.

The Lasso method was chosen for the selection of key financial indicators. The results discovered vital performance indicators of the studied sample. As it is necessary to pay attention to non-financial indicators when managing performance, the selection of financial indicators was supplemented by non-financial ones. Based on companies' business activities, four existing indices were supplemented with an environmental one according to the balanced scorecard methodology.

Therefore, future research should create a database of non-financial indicators for the industry and apply a suitable method to extract key non-financial performance indicators from the database. Also, the performance measurement system will be expanded to include the digitalization indicator focused on data collection in the business digitalization process.

AUTHOR CONTRIBUTIONS

Conceptualization: Jarmila Horváthová.
Data curation: Martina Mokrišová.
Formal analysis: Martina Mokrišová.
Funding acquisition: Jarmila Horváthová, Martina Mokrišová.

http://dx.doi.org/10.21511/ppm.21(3).2023.32

Investigation: Jarmila Horváthová.
Methodology: Martina Mokrišová.
Project administration: Martina Mokrišová.
Resources: Jarmila Horváthová, Martina Mokrišová.
Software: Martina Mokrišová.
Supervision: Jarmila Horváthová.
Validation: Jarmila Horváthová.
Visualization: Jarmila Horváthová, Martina Mokrišová.
Writing – original draft: Jarmila Horváthová.
Writing – review & editing: Jarmila Horváthová, Martina Mokrišová.

ACKNOWLEDGMENT

This paper is prepared within the grant scheme VEGA No. 1/0741/20 (the application of variant methods in detecting symptoms of possible bankruptcy of Slovak businesses in order to ensure their sustainable development).

REFERENCES

1. Ali, M. R. M. (2019). Balanced scorecard development over the last 26 years. *Journal of Business and Management, 21*(1), 13-16. Retrieved from https://www.iosrjournals.org/iosr-jbm/papers/Vol21-issue1/Series-4/B2101041316.pdf
2. AOSR. (2013). *Fungovanie a problémy v sektore tepelného hospodárstva v SR so zameraním na systémy CZT z pohľadu Protimonopolného úradu SR [Functioning and problems in the heat management sector in the Slovak Republic with a focus on local central heat supply systems from the perspective of the Antimonopoly Office of the Slovak Republic]*. (In Slovak). Retrieved from https://www.antimon.gov.sk/data/att/45d/365.c504f7.pdf?csrt=9982138273544634163
3. Azar, A., & Safari, S. (2021). Modelling business excellence through data envelopment analysis (DEA). *Management Research in Iran, 8*(33), 111-238. Retrieved from https://mri.modares.ac.ir/article_105.html?lang=en
4. Barroso, R., Burkert, M., Dávila, A., Oyon, D., & Schuhmacher, K. (2016). The moderating role of performance measurement system sophistication on the relationships between internal value drivers and performance. *Accounting, Auditing, Control, 22*(2), 39-75. Retrieved from https://www.cairn-int.info/journal-accounting-auditing-control-2016-2-page-39.htm
5. Bayaraa, B., Tarnoczi, T., & Fenyves, V. (2020). Corporate performance measurement using an integrated approach: A Mongolian case. *Montenegrin Journal of Economics, 16*(4), 123-134. https://doi.org/10.14254/1800-5845/2020.16-4.10
6. Behery, M., Jabeen, F., & Parakandi, M. (2014). Adopting a contemporary performance management system: A fast-growth small-to-medium enterprise (FGSME) in the UAE. *International Journal of Productivity and Performance Management, 63*(1), 22-43. https://doi.org/10.1108/IJPPM-07-2012-0076
7. Bititci, U. S., Carrie, A. S., & McDevitt, L. (1997). Integrated performance measurement systems: A development guide. *International Journal of Operations & Production Management, 17*(5), 522-534. https://doi.org/10.1108/01443579710167230
8. Bititci, U. S., Garengo, P., Döefler, V., & Nudurupati, S. (2012). Performance measurement: Challenges for tomorrow. *International Journal of Management Reviews, 14*(3), 305-327. https://doi.org/10.1111/j.1468-2370.2011.00318.x
9. Bourne, M., Mills, J., Wilcox, M., Neely, A., & Platts, K. (2000). Designing, implementing and updating performance measurement systems. *International Journal of Operations & Production Management, 20*(7), 754-771. https://doi.org/10.1108/01443570010330739
10. Bourne, M., Neely, A., Mills, J., & Platts, K. (2003). Implementing performance measurement systems: A literature review. *International Journal of Business Performance Management, 5*(1), 1-24. https://doi.org/10.1504/IJBPM.2003.002097
11. Brignall, T. J., Fitzgerald, L., Johnston, R., & Silvestro, R. (1991). Performance measurement in service businesses. *Management Accounting, 69*(10). Retrieved from http://wrap.warwick.ac.uk/79186/
12. Cao, Y., Liu, X., Zhai, J., & Hua, S. (2022). A two-stage Bayesian network model for corporate bankruptcy prediction. *International Journal of Finance & Economics, 27*(1), 455-472. https://doi.org/10.1002/ijfe.2162

13. CRIF. (2022). *Financial statements of analyzed businesses*. Bratislava: Slovak Credit Bureau, s.r.o.

14. da Silva, F. A., & Borsato, M. (2017). Organizational performance and indicators: Trends and opportunities. *Procedia Manufacturing, 11,* 1925-1932. https://doi.org/10.1016/j.promfg.2017.07.336

15. Das, P. K. (2019). Impact of balanced scorecard implementation on corporate performance. *American Journal of Humanities and Social Sciences, 17*(1), 1-9. Retrieved from https://worldscholars.org/index.php/ajhss/article/view/967/648

16. Geuser, F., Mooraj, S., & Oyon, D. (2009). Does the balanced scorecard add value? Empirical evidence on its effect on performance. *European Accounting Review, 18*(1), 93-122. https://doi.org/10.1080/09638180802481698

17. De Toni, A., & Tonchia, S. (2001). Performance measurement systems – Models, characteristics and measures. *International Journal of Operations & Production Management, 21*(1/2), 46-71. https://doi.org/10.1108/01443570110358459

18. Debdas, R. (2006). EVA based performance measurement: A case study of Dabur India Limited. *Vidyasagar University Journal of Commerce, 11,* 39-59. Retrieved from http://inet.vidyasagar.ac.in:8080/jspui/handle/123456789/960

19. Drucker, P. F. (1954). *The practice of management*. New York: Harper.

20. Dumitrescu, L., & Fuciu, M. (2009). Balanced scorecard – A new tool for strategic management. *Bulletin Scientific, 28*(2), 37-42.

21. Epstein, M. J. (1996). *Measuring corporate environmental performance: Best practices for costing and managing an effective environmental strategy*. Chicago, IL: Irwin.

22. Farooq, A., & Hussain, Z. (2011). Balanced scorecard perspective on change and performance: A study of selected Indian companies. *Procedia – Social and Behavioral Sciences, 24*, 754-768. https://doi.org/10.1016/j.sbspro.2011.09.043

23. Figge, F., Hahn, T., Schaltegger, S., & Wagner, M. (2002). The sustainability balanced scorecard – Linking sustainability management to business strategy. *Business Strategy and the Environment, 11*(5), 269-284. https://doi.org/10.1002/bse.339

24. Fonti, V., & Belitser, E. (2017). *Feature selection using LASSO* (Research Paper in Business Analytics). Vrije Universiteit Amsterdam. Retrieved from https://www.researchgate.net/profile/David-Booth-7/post/Regression-of-pairwise-trait-similarity-on-similarity-in-personal-attributes/attachment/5b18368d4cde260d15e3a4e3/AS%3A6346-06906785793%401528313485788/download/werkstuk-fonti_tcm235-836234.pdf

25. Fooladvand, M., Yarmohammadian, M. H., & Shahtalebi, S. (2015). The application strategic planning and balance scorecard modelling in enhance of higher education. *Procedia – Social and Behavioral Sciences, 186,* 950-954. https://doi.org/10.1016/j.sbspro.2015.04.115

26. Franco-Santos, M., Kennerley, M., Micheli, P., Martinez, V., Mason, S., Marr, B., Gray, D., & Neely, A. (2007). Towards a definition of a business performance measurement system. *International Journal of Operations & Production Management, 27*(8), 784-801. https://doi.org/10.1108/01443570710763778

27. Geng, S., Liu, S., & Liao, X. (2021). Operating performance of tourism listed companies in China: The perspective of economic value added. *SAGE Open, 11*(1). https://doi.org/10.1177/2158244020981064

28. Gosselin, M. (2005). An empirical study of performance measurement in manufacturing firms. *International Journal of Productivity and Performance Management, 54*(5/6), 419-437. https://doi.org/10.1108/17410400510604566

29. Guru, S., & Mahalik, D. K. (2019). A comparative study on performance measurement of Indian public sector banks using AHP-TOPSIS and AHP-grey relational analysis. *Operational Research Society of India, 56*(4), 1213-1239. https://doi.org/10.1007/s12597-019-00411-1

30. Gutierrez, D. M., Scavarda, L. F., Fiorencio, L., & Martins, R. A. (2015). Evolution of the performance measurement system in the logistics department of a broadcasting company: An action research. *International Journal of Production Economics, 160,* 1-12. https://doi.org/10.1016/j.ijpe.2014.08.012

31. Hastie, T., Tibshirani, R., & Friedman, J. (2009). *The elements of statistical learning: Data mining, inference, and prediction* (2nd ed.). Springer.

32. Hegazy, M., & Hegazy, S. (2012). The development of key financial performance indicators for U.K construction companies. *Accounting, Accountability & Performance, 17*(1&2), 49-77. Retrieved from https://ssrn.com/abstract=2450519

33. Heinz, A. (2001). Applying the balanced scorecard concept: An experience report. *Long Range Planning, 34*(4), 441-461. https://doi.org/10.1016/S0024-6301(01)00057-7

34. Horváthová, J., & Mokrišová, M. (2021). Creating performance measurement system with the application of balanced scorecard. In P. Doucek, G. Chroust, & V. Oškrdal (Eds.), *IDIMT 2021 – Pandemics: Impacts, Strategies and Responses. 29th Interdisciplinary Information Management Talks* (pp. 367-374). Kutná Hora, Czech Republic. Retrieved from https://idimt.org/wp-content/uploads/2021/08/IDIMT-2021-proceedings.pdf

35. Horváthová, J., & Suhányiová, A. (2012). Balanced scorecard – Nástroj riadenia podnikov a ich udržateľnosti v čase krízy [Balanced scorecard – A tool

http://dx.doi.org/10.21511/ppm.21(3).2023.32

for managing companies and their sustainability in times of crisis]. In S. Ferenčíková, H. Hansenová, J. Hvorecký, M. Tajtáková, M. Šestáková, J. Šimúth, & J. Palenčárová (Eds.), *Management Challenges in the 21th century, sustainability: A* moving target? (pp. 232-247). Trenčín: City University. (In Slovak). Retrieved from http://www.cutn.sk/Library/proceedings/mch_2012/editovane_prispevky/Horv%C3%A1thov%C3%A1_Suh%C3%A1nyiov%C3%A1.pdf

36. Horváthová, J., Mokrišová, M., & Suhányiová, A. (2013). *Hodnotenie výkonnosti podniku s využitím creditworthy modelu [Business performance evaluation using creditworthy model].* Prešov: Bookman, spol. s.r.o. (In Slovak).

37. Hsu, Y.-L., & Liu, Ch.-Ch. (2010). Environmental performance evaluation and strategy management using balanced scorecard. *Environmental Monitoring and Assessment, 170,* 599-607. https://doi.org/10.1007/s10661-009-1260-7

38. İç, Y. T., & Yurdakul, M. (2021). Development of a new trapezoidal fuzzy AHP-TOPSIS hybrid approach for manufacturing firm performance measurement. *Granular Computing, 6,* 915-929. https://doi.org/10.1007/s41066-020-00238-y

39. Johnson, H. T., & Kaplan, R. S. (1987). *Relevance lost: The rise and fall of management.* Boston: Harvard Business School Press Accounting.

40. Kaplan, R. S., & Norton, D. P. (1992). The balanced scorecard: Measures that drive performance. *Harvard Business Review, 70*(1), 71-79. Retrieved from https://hbr.org/1992/01/the-balanced-scorecard-measures-that-drive-performance-2

41. Kaplan, R. S., & Norton, D. P. (1996). *The balanced scorecard. Translating strategy into action.* Boston: Harvard Business School Press.

42. Kaplan, R. S., & Norton, D. P. (2001). The strategy-focused organization. *Strategy & Leadership, 29*(3). https://doi.org/10.1108/sl.2001.26129cab.002

43. Karpagam, P. L. U., & Suganthi, L. (2013). Performance measurement of organisations: A review of balanced scorecard technique. *International Journal of Business Performance Management, 14*(2), 129-148. https://doi.org/10.1504/IJBPM.2013.052940

44. Keegan, D. P., Eiler, R. G., & Jones, Ch. R. (1989). Are your performance measures obsolete? *Management Accounting, 70*(12), 45-50. Retrieved from https://www.proquest.com/docview/229823457?pq-origsite=gscholar&fromopenview=true

45. Keong Choong, K. (2013). Understanding the features of performance measurement system: A literature review. *Measuring Business Excellence, 17*(4), 102-121. https://doi.org/10.1108/MBE-05-2012-0031

46. Keong Choong, K. (2014). The fundamentals of performance measurement systems: A systematic approach to theory and a research agenda. *International Journal of Productivity and Performance Management, 63*(7), 879-922. https://doi.org/10.1108/IJPPM-01-2013-0015

47. Khanmohammadi, E., Safari, H., Zandieh, M., Malmir, B., & Tirkolaee E. B. (2022). Development of dynamic balanced scorecard using case-based reasoning method and adaptive neuro-fuzzy inference system. *IEEE Transactions on Engineering Management*. https://doi.org/10.1109/TEM.2022.3140291

48. Kraus, K., & Lind, J. (2010). The impact of the corporate balanced scorecard on corporate control – A research note. *Management Accounting Research, 21*(4), 265-277. https://doi.org/10.1016/j.mar.2010.08.001

49. Krivokapić, J., & Jovanović, J. (2009). Using balanced scorecard to improve environmental management system. *Journal of Mechanical Engineering, 55*(4), 262-271. Retrieved from https://www.sv-jme.eu/?id=4946&ns_articles_pdf=/ns_articles/files/ojs3/1578/submission/1578-1-1913-1-2-20171103.pdf

50. Krstić, B., Sekulić, V., & Ivanović, V. (2015). How to apply the sustainability balanced scorecard concept. *Economic Themes, 52*(1), 65-80. https://doi.org/10.1515/ethemes-2014-0005

51. Kucukaltan, B., Irani, Z., & Aktas, E. (2016). A decision support model for identification and prioritization of key performance indicators in the logistics industry. *Computers in Human Behavior, 65,* 346-358. https://doi.org/10.1016/j.chb.2016.08.045

52. Kumar, S., Attri, S. D., & Singh, K. K. (2019). Comparison of Lasso and stepwise regression technique for wheat yield prediction. *Journal of Agrometeorology, 21*(2), 188-192. https://doi.org/10.54386/jam.v21i2.231

53. Lee, S., Costello, F. J., & Lee, K. Ch. (2021). Hierarchical balanced scorecard-based organizational goals and the efficiency of controls processes. *Journal of Business Research, 132,* 270-288. https://doi.org/10.1016/j.jbusres.2021.04.038

54. Lesáková, Ľ. (2004). *Metódy hodnotenia výkonnosti malých a stredných podnikov [Methods for evaluating the performance of small and medium businesses].* Banská Bystrica: Matej Bel University. (In Slovak).

55. Lynch, R. L., & Cross, K. F. (1991). *Measure up! Yardsticks for continuous improvement*. Oxford: Blackwell.

56. Madsen, D. Ø., & Stenheim, T. (2015). The balanced scorecard: A review of five research areas. *American Journal of Management, 15*(2), 24-41. Retrieved from http://www.www.na-businesspress.com/AJM/MadsenDO_Web15_2_.pdf

57. Mařík, M., & Maříková, P. (2005). *Moderní metody hodnocení výkonnosti a oceňování podniku: Ekonomická přidaná hodnota, tržní přidaná hodnota, CF ROI [Modern methods of performance*

evaluation and business valuation: Economic value added, market value added, CF ROI] (2nd ed.). Prague: Ekopress. (In Czech).

58. Meng, J., Zhang, J., Xiu, Y., Jin, Y., Xiang, J., Nie, Y., Fu, S., & Zhao, K. (2018). Prognostic value of an immunohistochemical signature in patients with esophageal squamous cell. *Molecular Oncology, 12*(2), 196-207. https://doi.org/10.1002/1878-0261.12158

59. Mikušová, M., & Janečková, V. (2010). Developing and implementing successful key performance indicators. *World Academy of Science, Engineering and Technology, 42,* 969-981. Retrieved from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=2b0b809a7c5b6eff80a2aa4768b47154949e3251

60. Mokrišová, M., & Horváthová, J. (2021). The creation of a financial management map for business performance improvement. *Proceedings of the 10th International Conference on Management and Economics* (pp. 105-116) Matara: University of Ruhuna. Retrieved from http://ir.lib.ruh.ac.lk/handle/iruor/3680

61. Mooraj, S., Oyon, D., & Hostettler, D. (1999). The balanced scorecard: A necessary good or unnecessary evil? *European Management Journal, 17*(5), 481-491. https://doi.org/10.1016/S0263-2373(99)00034-1

62. Nastasiea, M., & Mironeasa, C. (2016). Key performance indicators in small and medium sized enterprises. *TEHNOMUS – New Technologies and Products in Machine Manufacturing Technologies.* Retrieved from https://docplayer.net/42958617-Key-performance-indicators-in-small-and-medium-sized-enterprises.html

63. Neely, A. (1999). The performance measurement revolution: Why now and what next? *International Journal of Operations & Production Management, 19*(2), 205-228. https://doi.org/10.1108/01443579910247437

64. Neely, A. (2005). The evolution of performance measurement research: Developments in the last decade and a research agenda for the next. *International Journal of Operations & Production Management, 25*(12), 1264-1277. https://doi.org/10.1108/01443570510633648

65. Neely, A., Gregory, M., & Platts, K. (1995). Performance measurement system design: A literature review and research agenda. *International Journal of Operations & Production Management, 15*(4), 80-116. https://doi.org/10.1108/01443579510083622

66. Neely, A., Marr, B., Roos, G., Pike, S., & Gupta, O. (2003). Towards the third generation of performance measurement. *Controlling, 15*(3-4), 129-136. https://doi.org/10.15358/0935-0381-2003-3-4-129

67. Neely, A., Mills, J., Platts, K., Gregory, M., & Richards, H. (1996). Performance measurement system design: Should process based approaches be adopted? *International Journal of Production Economics, 46-47,* 423-431. https://doi.org/10.1016/S0925-5273(96)00080-1

68. Neumaierová, I., & Neumaier, I. (2002). *Výkonnost a tržní hodnota firmy [Performance and market value of the company].* Prague: Grada Publishing. (In Czech).

69. Nguyen, Y-H., & Luu, Q. C. (2021). Performance measurement of Vietnamese publishing firms by the integration of the GM (1,1) model and the Malmquist model. *Business Systems Research Journal, 12*(1), 17-33. https://doi.org/10.2478/bsrj-2021-0002

70. Nudurupati, S. S., Bititci, U. S., Kumar, V., & Chan, F. T. S. (2011). State of the art literature review on performance measurement. *Computers and Industrial Engineering, 60*(2), 279-290. https://doi.org/10.1016/j.cie.2010.11.010

71. Oukhay, F., & Romdhane, T. B. (2022). A decision support framework based on FCM for selecting key performance indicators. *Proceedings of the 5th International Conference on Advanced Systems and Emergent Technologies* (pp. 97-102). Hammamet, Tunisia. https://doi.org/10.1109/IC_ASET53395.2022.9765915

72. Paraschiv, F., Schmid, M., & Wahlstrøm, R. R. (2021). Bankruptcy prediction of privately held SMEs using feature selection methods. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.3911490

73. Peng, Y., & Zhou, L. (2011). A performance measurement system based on BSC. In M. Zhu (Ed.), *Information and Management Engineering* (pp. 309-315). Springer. https://doi.org/10.1007/978-3-642-24022-5_50

74. Pereira, J. M., Basto, M., & Ferreira da Silva, A. (2016). The logistic Lasso and Ridge regression in predicting corporate failure. *Procedia Economics and Finance, 39,* 634-641. https://doi.org/10.1016/S2212-5671(16)30310-0

75. Rapach, D. E., Strauss, J. K., & Zhou, G. (2013). International stockreturn predictability: What is the role of the United States? *The Journal of Finance, 68*(4), 1633-1662. https://doi.org/10.1111/jofi.12041

76. Robinson, H. S., Anumba, C. J., Carrillo, P. M., & Al-Ghassani, A. M. (2005). Business performance measurement practices in construction engineering organisations. *Measuring Business Excellence, 9*(1), 13-22. https://doi.org/10.1108/13683040510588800

77. Rosová, A., & Balog, M. (2012). Traditional and modern methods and approaches to the evaluation of company performance. *Proceedings of the Carpathian Logistics Congress*. Jeseník, Czech Republic. Retrieved from http://masters.donntu.ru/2015/fknt/matiakh/library/article5.pdf

78. Sainaghi, R., Phillips, P., & Corti, V. (2013). Measuring hotel performance: Using a balanced scorecard perspectives' approach. *International Journal of Hospitality Management, 34,* 150-159. https://doi.org/10.1016/j.ijhm.2013.02.008

http://dx.doi.org/10.21511/ppm.21(3).2023.32

79. Shutibhinyo, W. (2012). An exploratory study of balanced scorecard practices: Preliminary evidence from Thailand. *Asia-Pacific Management Accounting Journal, 7*(1). Retrieved from https://ir.uitm.edu.my/id/eprint/10815/1/10815.pdf

80. Silvi, R., Bartolini, M., Raffoni, A., & Visani, F. (2015). The practice of strategic performance measurement systems: Models, drivers and information effectiveness. *International Journal of Productivity and Performance Management, 64*(2), 194-227. https://doi.org/10.1108/IJPPM-01-2014-0010

81. Singh, R. K., & Arora, S. S. (2018). The adoption of balanced scorecard: An exploration of its antecedents and consequences. *Benchmarking: An International Journal, 25*(3), 874-892. https://doi.org/10.1108/BIJ-06-2017-0130

82. Soderberg, M., Kalagnanam, S., Sheehan, N.T., & Vaidyanathan, G. (2011). When is a balanced scorecard a balanced scorecard? *International Journal of Productivity and Performance Management, 60*(7), 688-708. https://doi.org/10.1108/17410401111167780

83. Song, X. (2022). Application of balanced scorecard in performance management and evaluation of listed companies. *Discrete Dynamics in Nature and Society, 2022,* 2247890. https://doi.org/10.1155/2022/2247890

84. Strelnik, E. U., Usanova, D. S., & Khairullin, I. G. (2015). Key performance indicators in corporate finance. *Asian Social Science, 11*(11), 369-373. https://doi.org/10.5539/ass.v11n11p369

85. Tian, S., Yu, Y., & Guo, H. (2015). Variable selection and corporate bankruptcy forecasts. *Journal of Banking & Finance, 52,* 89-100. https://doi.org/10.1016/j.jbankfin.2014.12.003

86. Tuan, T. T. (2020). The impact of balanced scorecard on performance: The case of Vietnamese commercial banks. *Journal of Asian Finance, Economics and Business, 7*(1), 71-79. Retrieved from https://www.econbiz.de/Record/the-impact-of-balanced-scorecard-on-performance-the-case-of-vietnamese-commercial-banks-tran-trung-tuan/10012667200

87. Tudose, M. B., Rusu, V. D., & Avasilcai, S. (2021). Performance management for growth: A framework based on EVA. *Journal of Risk and Financial Management, 14*(3), 102. https://doi.org/10.3390/jrfm14030102

88. Vadovský, M., Paralič, J., & Gross, A. (2018). Spracovanie a analýza dát z mobilnej aplikácie na sledovanie kognitívnych príznakov Parkinsonovej choroby [Processing and analysis of data from a mobile application to monitor the cognitive symptoms of Parkinson's disease]. In J. Šaliga & E. Pietriková (Eds.), *Electrical Engineering and Informatics IX* (pp.353-358). Faculty of Electrical Engineering and Informatics. (In Slovak). Retrieved from https://www.researchgate.net/publication/326635658_Spracovanie_a_analyza_dat_z_mobilnej_aplikacie_na_sledovanie_pohybovych_priznakov_Parkinsonovej_choroby

89. Valmohammadi, C., & Servati, A. (2011). Performance measurement system implementation using balanced scorecard and statistical methods. *International Journal of Productivity and Performance Management, 60*(5), 493-511. https://doi.org/10.1108/17410401111140400

90. Verevka, T. (2018). Key performance indicators of high-tech enterprises. *SHS Web of Conferences*, *44,* 00077. https://doi.org/10.1051/shsconf/20184400077

91. Vilanova, M. R. N., Filho, P. M., & Balestieri, J. A. P. (2015). Performance measurement and indicators for water supply management: Review and international cases. *Renewable and Sustainable Energy Reviews, 43,* 1-12. https://doi.org/10.1016/j.rser.2014.11.043

92. Vochozka, M., Jelínek, J., Váchal, J., Straková, J., & Stehel, V. (2017). *Využití neuronových sítí při komplexním hodnocení podniků [The use of neural networks in comprehensive business evaluation].* Praha: C. H. Beck. (In Czech).

93. Wu, H-Y., Lin, Y-K., & Chang, C-H. (2011). Performance evaluation of extension education centers in universities based on the balanced scorecard. *Evaluation and Program Planning, 34*(1), 37-50. https://doi.org/10.1016/j.evalprogplan.2010.06.001

94. Zare, H., Tavana, M., Mardani, A., Masoudian, S., & Saraji, M. K. (2019). A hybrid data envelopment analysis and game theory model for performance measurement in healthcare. *Health Care Management Science, 22,* 475-488. https://doi.org/10.1007/s10729-018-9456-4

95. Zhou, L., Lu, D., & Fujita, H. (2015). The performance of corporate financial distress prediction models with features selection guided by domain knowledge and data mining approaches. *Knowledge-Based Systems, 85,* 52-61. https://doi.org/10.1016/j.knosys.2015.04.017