

## EXPLORING THE EFFECTIVENESS OF ARIMA MODELS IN PREDICTING INTEREST RATES IN SLOVAKIA

Dominika Gajdosikova<sup>1,a,\*</sup>

<sup>1</sup>University of Zilina, Faculty of Operation and Economics of Transport and Communications,  
Department of Economics, Univerzitna 1, 010 26 Zilina, Slovakia

<sup>a</sup>dominika.gajdosikova@uniza.sk

\*Corresponding author

**Cite as:** Gajdosikova, D. (2025). *Exploring the Effectiveness of ARIMA Models in Predicting Interest Rates in Slovakia*, *Ekonomicko-manazerske spektrum*, 19(1), 1-13.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.1-13](https://dx.doi.org/10.26552/ems.2025.1.1-13)

---

*Received: 9 November 2024; Received in revised form: 5 February 2025; Accepted: 21 February 2025; Available online: 30 June 2025*

### Abstract:

**Research background:** Predicting movements in interest rates is of paramount importance to financial and economic planning. Accurate predictions allow policymakers, financial institutions, and businesses to make efficient investment decisions, risk management, and fiscal policy. Predicting movements in interest rates assists in providing useful information for the realignment of monetary policies and the optimization of capital allocation during times of uncertainty.

**Purpose of the article:** The aim of this paper is to fill a gap in the literature and examine the use of the ARIMA model to predict interest rates in Slovakia, a country subject to domestic as well as EU economic factors.

**Methods:** The ARIMA model is utilized within this study to forecast Slovak interest rates to test how accurate it can be in measuring Slovak interest rate intricate dynamics, which arise due to both EU and local monetary policy interventions. Traditional calibration metrics such as MAE, RMSE, and MAPE are used to gauge its precision in forecasting. The result provides information about the efficiency and limitations of using ARIMA as an instrument of economic forecasting in the Slovak context.

**Findings & Value added:** The ARIMA(2,1,1) model worked exceptionally well in interest rate prediction for Slovakia, explaining 99.1% of the variance with very low RMSE at 0.085 and MAPE at 1.864%. Significant coefficients, such as AR(1) 0.984 and MA(1) 0.692, indicate the success of the model in capturing the underlying time series dynamics. The Ljung-Box test also confirmed the existence of non-significant autocorrelation among the residuals, confirming the model's stability and reliability in economic forecasting. Practically, these findings are useful to policymakers, banks, and businesses in Slovakia, as accurate interest rate forecasts in guiding investment plans, credit risk, and fiscal policy. The findings underscore the need to utilize strong forecasting models like ARIMA to adjust policies in a setting dominated by both EU and domestic economics to enable economic choices to be guided by up-to-date information.

**Keywords:** interest rate prediction; monetary policy; economic dynamics; ARIMA model; Slovakia

**JEL Classification:** C22; E37; E43

## **1. Introduction**

Interest rates are the most significant drivers of the economic climate, affecting everything from the borrowing patterns of individuals to the general dynamics of the financial markets. Primary drivers of changes in interest rates are inflationary expectations, economic growth, monetary policy, and risk premiums. Inflation, being the most proximate cause of interest rates, leads central banks to raise rates to offset inflationary pressures, while an episode of low inflation has the effect of leading to rate cuts to encourage economic growth. Economic growth and unemployment are also significant, as a surging economy can necessitate higher interest rates to prevent overheating, whereas, in an economic recession, central banks will seek to lower rates to encourage borrowing and investment. Central banks, such as the European central bank (ECB), heavily influence short- and long-term interest rates by their policy maneuvers. Monetary policy tools such as changes in interest rates or quantitative easing form the backbone of inflation management and economic stabilization (Duran and Gajewski, 2023; Frajtova Michalikova et al., 2024). The trajectory of interest rates in Slovakia, in particular, has been determined not only by the domestic economic setting but also by the broader European monetary policy setting, global financial crises, and even external shocks like the COVID-19 pandemic.

Earlier literature in interest rate modelling had seminal works such as Fauvel et al. (1999), who provided a survey of the empirical literature. Bidarkota (1998) derived a univariate unobserved components model for U.S. real interest rates, which stated that an error-correction model yielded better one-step-ahead forecast accuracy of the real rate, but unobserved components models generated lower variance of forecast values. These early models set the stage for the more advanced methods of interest rate prediction. Similarly, Butter and Jansen (2004) studied long-term German government bond yields with macroeconomic explanatory variables such as German 3-month Libor, US 10-year yields, and the German IFO business activity indicator. Although they were holistic in their approach, the models were limited by their inability to forecast macroeconomic trends, owing to issues such as data distortion during the quarterly calculation of the government balance. With advancements in interest rate modelling, researchers like Dua and Pandit (2002) focused on the Indian short- and long-term interest rate dynamics, formulating co-integrating relationships among real interest rates, money supply, and foreign interest rates. Their empirical findings confirmed the role of domestic and external variables in determining interest rates. In another research, Dua et al. (2004) forecasted models for 10-year Indian government security yields and determined that vector autoregressive (VAR) models performed better than vector error correction model (VECM) models, particularly due to the small sample size and continuous decline of interest rates during the sample period. These early studies helped refine variables and models used for interest rate forecasting, with an emphasis on foreign and domestic financial indicator interaction.

Recently, the application of machine learning has transformed interest rate modeling with its adoption of alternative data sources and elaborate algorithms. Yasir et al. (2020) applied a deep learning model that incorporated sentiment information from sources like Twitter-based online forums to forecast interest rates. They observed the inclusion of sentiment significantly improving prediction power, especially amid turmoil like Hong Kong, pointing towards the application of machine learning to collate alternative data sources. This contrasts with traditional econometric models, where past financial data is relied upon completely. The superiority of machine learning techniques in interest rate prediction has also been indicated in earlier research. For instance, Tang (2023) examined the use of artificial neural networks (ANN) for financial market prediction and found that machine learning models performed

particularly well with non-linear relationships as well as high-dimensional data. Similarly, Shen et al. (2021) and Makika et al. (2023) found that deep learning algorithms like long short-term memory (LSTM) networks could identify complex, non-linear patterns in finance data with better accuracy than traditional econometric models. While these advances in machine learning have brought encouraging outcomes, comparative analyses of different machine learning models are still needed, particularly for interest rate forecasting. In addition, computational cost, quality of data, and interpretability of models are still concerns. As shown in the work of Udoeye et al. (2020), attempts at merging traditional econometric models with machine learning have sought to be transparent while increasing accuracy, but there are challenges in the full optimization of such hybrid approaches.

Several approaches have been developed to forecast interest rates, and among them, the autoregressive integrated moving average (ARIMA) model is one of the most widely employed. The ARIMA models are extremely popular since they can model and forecast time series data describing both long-term patterns and short-term relationships (Xie et al., 2022; Kolkova and Rozehnal, 2022). The model incorporates three principal components: (i) autoregression to represent the relationship between present and past observations (Rajab et al., 2022); (ii) integration, used for the reduction of non-stationary series to a stationary form through differencing (Kumar and Hariharan, 2022); and (iii) moving average to represent the relationship between an observation and past forecast errors (Tarmanini et al., 2023). The simplicity, interpretability, and effectiveness of ARIMA make it a strong candidate for time series forecasting, including interest rate forecasting. While ARIMA remains a favorite method, other time series modelling methods have also been used in interest rate forecasting. The generalized autoregressive conditional heteroscedasticity (GARCH) model is usually used for financial time series, particularly when volatility and heteroscedasticity must be modelled in the data (Ray et al., 2023). According to Cekin et al. (2024), GARCH models are excellent at modelling time-varying volatility, which is common in financial markets. Another approach that is commonly applied is the VAR model, which defines the relationship between multiple time series variables (Krishnan et al., 2024). The model is particularly useful when interest rates are influenced by a variety of macroeconomic variables, such as inflation, GDP, or exchange rates. In addition, machine learning techniques such as random forests, support vector machines, and deep learning algorithms have gained popularity recently due to their ability to recognize complex non-linear patterns in data. Yamacli and Yamacli (2023) concluded in their study that the ARIMA model is distinguished by the fact that it is extremely simple and interpretable, making it a favorite for economic forecasting. Different studies have managed to apply ARIMA models in forecasting interest rates across the globe, including in the United States (Gozgor, 2013), Europe (Guerrero et al., 2023; Hubik, 2024), and emerging economies (Alfaro et al., 2011). For instance, previous studies have established ARIMA's robustness in modelling interest rate behavior and its capacity to provide precise forecasts following domestic and foreign economic shocks. In Slovakia, the ARIMA model can uncover valuable information concerning how interest rates evolve in response to ECB policy, inflation trends, and other macroeconomic dynamics.

This paper aims to present a significant gap in the current literature by trying to examine the application of the ARIMA model in interest rate forecasting in Slovakia. While the ARIMA model has been widely used across various economic settings, with fairly few specifically considering its ability to capture the complex dynamics of interest rate movements in the case of Slovakia, which is highly influenced by both domestic economic forces as well as monetary policy in the European Union. The primary purpose of this study is to evaluate the performance of ARIMA based on standard performance metrics, such as mean absolute error (MAE), root

mean squared error (RMSE), and mean absolute percentage error (MAPE). Through the evaluation, the paper seeks to provide a complete judgment of the strengths and weaknesses of ARIMA for economic forecasting, particularly on Slovak interest rates. In doing so, this research will contribute to the current literature base in time series forecasting with a focus on the relevance of ARIMA in providing precise and meaningful forecasts of interest rate changes. Last, the findings will serve to be beneficial for policy-making, financial planning, and research in the area in the future, filling an intriguing gap in interest rate forecasting literature for Slovakia and comparable economies.

The following sections comprise the paper. The first section is a literature review, introducing the primary theoretical framework of the topic and emphasizing recent relevant studies in the area. The second section is a description of the methods used to fulfill the objectives of the paper, with particular reference to the application of the ARIMA model to forecast interest rates and also the criteria to be employed to assess the performance of the model. The third part presents the results of implementing the ARIMA model, including an accuracy analysis of the prediction and a comparison with other models. Finally, the paper summarizes the findings, constraints, and potential future study areas.

## **2. Methodology**

The main aim of this paper is to analyze the application of the ARIMA model in time series forecasting, with a particular focus on predicting the evolution of interest rates in Slovakia. The study will critically analyze the performance of the ARIMA model based on conventional measures of forecasting performance. Furthermore, the paper examines the ability of the model to capture the underlying temporal structures of interest rate movements and provides insights into the reliability and accuracy of ARIMA-based forecasts in economic forecasting.

The data used for analysis here are monthly interest rates in Slovakia from January 2010 through December 2024. The data were gathered from the National Bank of Slovakia and are 180 observations in total, where each observation is the value of an interest rate for a given month. This one series of univariate information captures the historic volatility of interest rates for nearly 15 years, through all economic cycles, growth, recession, and external shocks such as the COVID-19 pandemic. The data set is a comprehensive base to analyze trends, patterns, and potential structural changes in the Slovak interest rate prediction.

The data were pre-processed prior to using it by dealing with any missing values and ensuring that the data were stationarized. Stationarity is essential in ARIMA models because the mean and variance of the series need to remain unchanged over time. If the series is not stationary, we make it stationary through differencing, which takes us to the next step (Adebiyi et al., 2014).

To appropriately apply the ARIMA model, the autoregressive, differencing, and moving average order should be ascertained from the observation of the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the time series (Kumar and Vanajakshi, 2015). The autoregressive term ( $p$ ) is the correlation between a point and several lagged points, as indicated by the PACF plot (Pang et al., 2020). Differencing ( $d$ ) is employed to make the series stationary (Apley and Shi, 1999), and the Augmented Dickey-Fuller test is employed to identify the order of differencing (Kumar et al., 2022). The moving average component ( $q$ ) captures the effect of an observation on the residual errors of a moving average model, and the ACF plot is employed to identify the optimal number of lagged forecast errors.

According to Alomari et al. (2023), after the values of  $p$ ,  $d$ , and  $q$  were determined, the ARIMA model was then used to fit the historical interest rate data. The ARIMA model can be mathematically represented as:

$$(1 - B)^d Y_t = \mu + \Phi(B)(1 - B)^d Y_t = \mu + \Phi(B)Z(t) + \Theta(B)\epsilon_t \quad (1)$$

where  $\Phi(B)$  represents the autoregressive operator of order  $p$ , that is

$$\Phi(B) = 1 - \varphi_1 B - \varphi_2 B^2 - \dots - \varphi_p B^p \quad (2)$$

$\Theta(B)$  represents the moving average operator of order  $q$ , that is

$$\Theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q \quad (3)$$

$Z(t)$  is white noise process with zero mean and constant variance  $\sigma^2$  and  $\epsilon_t$  is the error term.

An ARIMA model necessitates that the time series be stationary, or have a constant mean and variance over time. The  $d$  in ARIMA refers to differencing, which is a process that is used to render the series stationary when it isn't. Differencing involves the computation of the difference between successive observations ( $Y_t - Y_{t-1}$ ). If the series is still non-stationary after one round of differencing, it is possible to repeat this operation, as suggested by the  $d$  value in the ARIMA( $p, d, q$ ) model (Kumar et al., 2022). The ARIMA model can be stated in the alternative form:

$$Y_t = c + \varphi_1 Y_{t-1} + \dots + \varphi_p Y_{t-p} + \dots + \theta_1 \epsilon_{t-1} + \dots + \theta_q \epsilon_{t-q} + \epsilon_t \quad (4)$$

where  $Y_t$  is the observation at time  $t$ ,  $\varphi_j$  is the parameter of the autoregressive part of the model,  $\theta_k$  is the parameter of the moving average part, and  $\epsilon_t$  is the error term.

After training the model, residuals are tested for patterns or a deviation from white noise, which might suggest model inadequacy. The Ljung-Box test and plots of the residuals were employed to validate that the model has picked up all the important autocorrelations in the data.

The final step is to use the estimated ARIMA model to forecast future interest rates in Slovakia. The predicted values are augmented by upper and lower control limits (UCL and LCL) to represent the prediction intervals for each forecast point (Christo et al., 2013). These intervals provide an interval where the true interest rate will be with some specified confidence level.

Evaluation metrics serve an important function in gauging the performance of statistical or machine-learning models through the comparison of observations with expected values. The choice of what metric to employ depends on the specific nature of the problem one is addressing since they perform distinct functions. Wang (2008) concluded that many evaluation metrics have historically been used in regression models.

Mean absolute error (MAE) is the simplest and most intuitive of regression metrics. It calculates the average of absolute differences between observed and predicted values, providing a straight-line measure of prediction error size (Kozuch et al., 2023). The formula for MAE is:

$$MAE = \frac{1}{n} \sum_{i=1}^n |Y_i - F_i| \quad (5)$$

where  $Y_i$  is the observed value,  $F_i$  is the forecasted value, and  $n$  is the number of observations.

Mean absolute percentage error (MAPE) is helpful if it is desirable to express the error as a fraction of the size of the observed value (Ray et al., 2023). It is particularly helpful if the data are on varying scales and is given by:

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{Y_i - F_i}{Y_i} \right| \quad (6)$$

Root mean squared error (RMSE) is, according to Noorunnahar et al. (2023), yet another well-liked metric that penalizes larger mistakes by squaring the differences between observed and predicted values. It is particularly valuable if large errors are unwanted. The formula for RMSE is:

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (Y_i - F_i)^2} \quad (7)$$

The coefficient of determination (R-squared) measures the proportion of the variance in the observed data explained by the model. It indicates how well the model fits the data, with high values being indicative of a good fit (Rezaei and Shabri, 2024). R-squared is given by:

$$R - squared = 1 - \frac{\sum_{i=1}^n (Y_i - F_i)^2}{\sum_{i=1}^n (Y_i - \bar{Y})^2} \quad (8)$$

where  $\bar{Y}$  is the mean of the observed values.

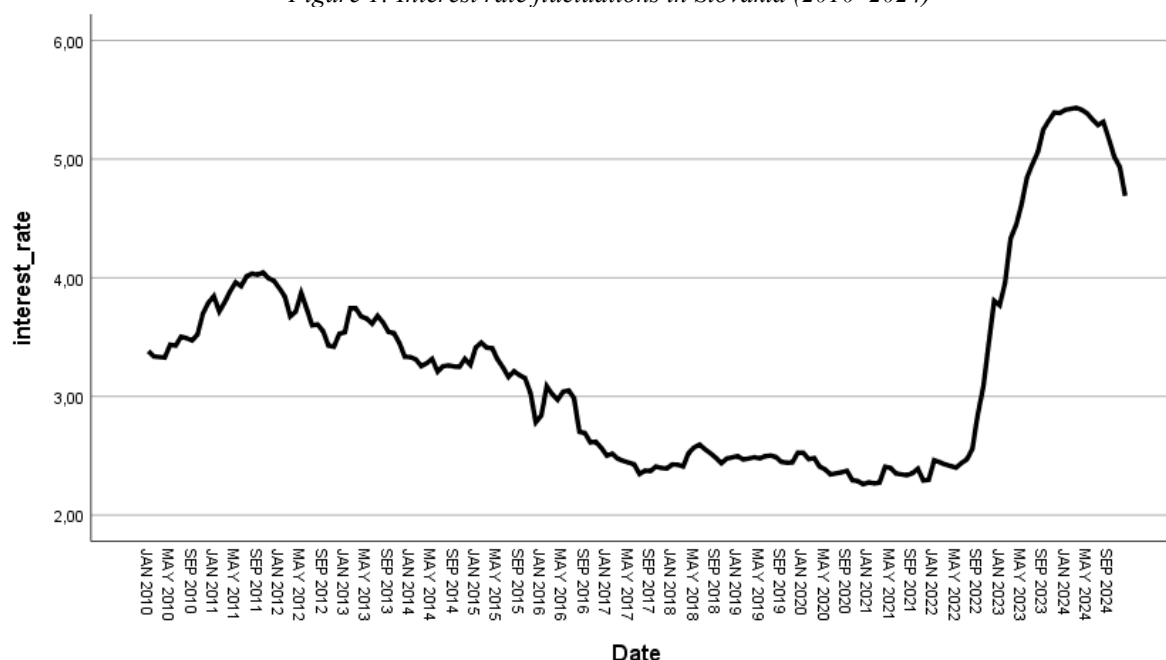
### 3. Results and Discussion

Figure 1 presents how the interest rate evolved in Slovakia between January 2010 and December 2024 and represents various economic developments. Between 2010 and 2013, interest rates gradually increased due to economic recovery from the global financial crisis, with the peak coming in late 2011. Between 2014 and 2015, the rates declined steadily due to the accommodative monetary policy of the ECB in response to low inflation and sluggish economic growth. Between 2016 and 2019, interest rates remained low due to the ECB's continuous efforts to stimulate the economy. The onset of the COVID-19 pandemic in 2020 led to subsequent rate reductions to soften the economic downturn. The record-low rate was felt during December 2020. In 2021 and 2022, as the economy started to rebound, rates began to climb because of inflationary pressures driven by supply chain shocks and elevated energy prices. By 2023 and 2024, interest rates surged again because of chronic inflation, reaching 4.69% as of December 2024. This pattern highlights the impact of foreign and domestic factors on the interest rates in Slovakia in the past decade.

High autocorrelation was observed in the ACF and PACF plots of the time series with a high value of 0.987 at lag 1, showing that the data is non-stationary. The PACF indicated that an order of 1 autoregression was suitable. Based on these observations, first-order differencing of the data was done to eliminate trends and to make it stationary for further model fitting.

After differencing the time series, the ACF showed severe autocorrelation at the first few lags, with the highest value being 0.408 at lag 1, indicating a moderate autocorrelation. Autocorrelation decreased smoothly at subsequent lags, i.e., correlation decreased. The PACF showed that partial correlations were small at lags higher than 1, where values at lag 2 and

Figure 1: Interest rate fluctuations in Slovakia (2010–2024)



Source: National Bank of Slovakia (n.d.)

beyond were close to zero. Based on the results, the optimal model was selected as ARIMA(2,1,1).

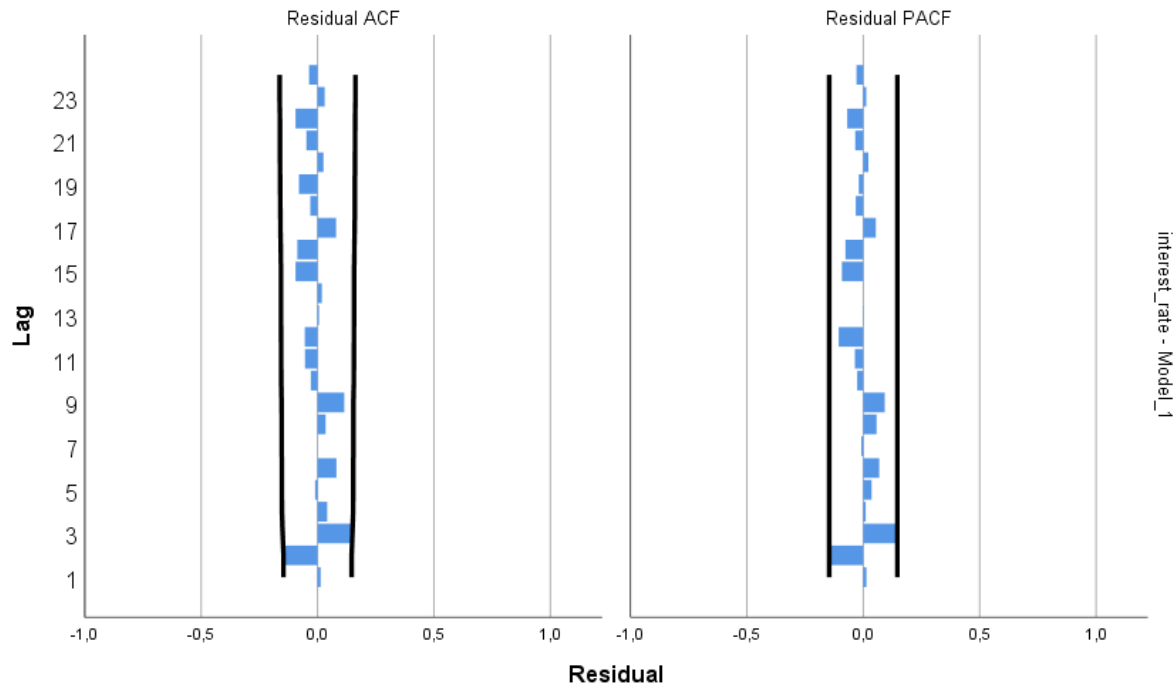
ARIMA(2,1,1) fits the data very well with 99.1% variance explained. RMSE is minimal at 0.085, and predictions are, therefore, correct. MAPE is 1.864%, showing minimal average deviation from actual values. A normalized BIC of -4.815 shows a balance between model fit and simplicity. The high value of the large AR(1) coefficient value of 0.984 and MA(1) coefficient of 0.692 indicates the model's largest autoregressive and moving average characteristics. The Ljung-Box test confirms any noteworthy autocorrelation among the residuals, indicating that the model accounts for the time series behaviour properly.

The residual ACF and PACF (Figure 2) show that the ARIMA(2,1,1) model has successfully captured the patterns in the time series. Most of the autocorrelations and partial autocorrelations are close to zero, and none of them is outside the standard error range. While there are minor fluctuations at some of the lags (e.g., lags 1 and 3), they do not suggest any autocorrelation, which means the residuals are about white noise, and the model interpolates the data well, leaving no significant residual temporal structure.

The prediction of the interest rate, as forecasted by the ARIMA(2,1,1) model, is a gradual reduction in the forthcoming year. Beginning at 4.59% in January 2025, the interest rate will continue to drop steadily to 4.00% in December 2025. The UCL fluctuates between 4.75% in January and 5.20% in December, and the LCL reduces from 4.42% in January to 2.79% in December. These forecasted values, along with the confidence intervals, provide the anticipated trend and the associated uncertainty over the forecast horizon, as given in Table 1 and Figure 3.

Within the Slovak situation, the predicted decrease in interest rates is additionally consistent with broader economic trends, such as European Central Bank policy and inflation stabilization. Slovakia, along with other Eurozone nations, has experienced increasing and decreasing interest rates over the past several years, largely influenced by the ECB's monetary policy interventions aimed at controlling inflation and improving economic growth. The forecasted decline illustrates the potential for monetary policy relaxation, which can lead to more accommodative

Figure 2: Residual ACF and PACF of the ARIMA Model



Source: own elaboration

borrowing conditions for Slovak consumers and businesses. The uncertainty reflected in the confidence intervals, however, indicates the volatility of economic conditions, with an emphasis on the need for continued monitoring of exogenous variables that will influence future interest rates.

Table 1: Forecast of interest rates with UCL and LCL for 2025

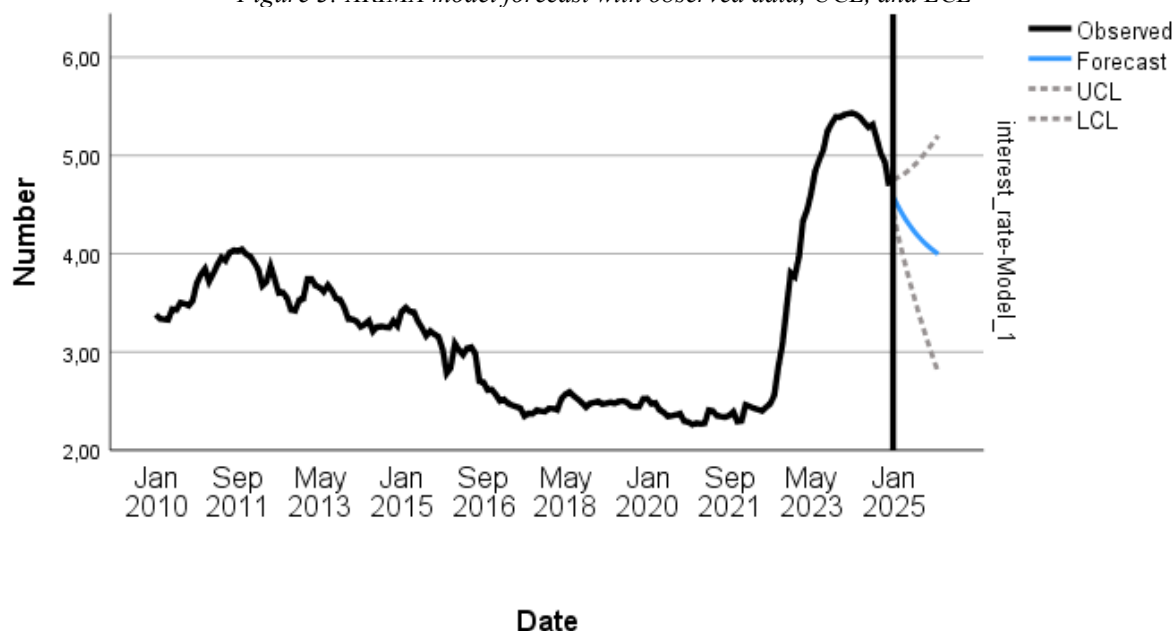
|          | Jan 2025 | Feb 2025 | Mar 2025 | Apr 2025 | May 2025 | Jun 2025 |
|----------|----------|----------|----------|----------|----------|----------|
| Forecast | 4.59     | 4.50     | 4.42     | 4.35     | 4.29     | 4.23     |
| UCL      | 4.75     | 4.77     | 4.80     | 4.82     | 4.86     | 4.89     |
| LCL      | 4.42     | 4.23     | 4.05     | 3.88     | 3.73     | 3.58     |
|          | Jul 2025 | Aug 2025 | Sep 2025 | Oct 2025 | Nov 2025 | Dec 2025 |
| Forecast | 4.18     | 4.14     | 4.10     | 4.06     | 4.03     | 4.00     |
| UCL      | 4.94     | 4.98     | 5.03     | 5.09     | 5.14     | 5.20     |
| LCL      | 3.43     | 3.29     | 3.16     | 3.03     | 2.91     | 2.79     |

For each model, forecasts start after the last non-missing in the range of the requested estimation period, and end at the last period for which non-missing values of all the predictors are available or at the end date of the requested forecast period, whichever is earlier.

Source: own elaboration

Xiao and Pang (2017) used a structural vector autoregression model to analyse the influence of expected and unexpected monetary policy shocks on Chinese real estate prices. They found that unexpected interest rate changes had a more immediate and significant effect, while expected shocks were less as they had been priced into market expectations. Canpolat (2022) used the log-normal variable ARIMA model to predict the weighted average funding cost of Turkey's Central Bank and concluded that the nonlinear model performed better than conventional ARIMA in terms of prediction accuracy, particularly in times of economic change. Hua et al. (2020) compared the Nelson-Siegel model and a neural network model in predicting the RMB exchange rate and concluded the latter to be more effective, performing better with greater predictive accuracy through lower MAPE and RMSE values. Mallick and Mishra (2019) used a principal analysis component ARIMA hybrid model in interest rate prediction in India

Figure 3: ARIMA model forecast with observed data, UCL, and LCL



Source: own elaboration

and obtained improved prediction accuracy through macroeconomic trend capture. Liang et al. (2022) combined ARIMA and convolutional neural network models to predict the RMB exchange rate, achieving significant prediction improvements with MAPE values less than 2%, showing the value of combining deep learning with traditional models. Ahmed et al. (2017) used the ARIMA model to forecast KIBOR in Pakistan, achieving high precision with a MAPE of 1.92%.

Abounoori and Tazehabadi (2009) used a hybrid model that combined autoregressive distributed lag (ARDL), ARIMA, and ANN to predict stock prices from macro variables and illustrated combined approach greatly improved the forecasting accuracy. Paik and Ko (2024) applied ARIMA, seasonal autoregressive integrated moving average (SARIMA), and GARCH models in the analysis of Credit Guarantee Funds in Korea, and SARIMA was superior to ARIMA, particularly in the seasonal periods with MAPE below 3%. Zasadnyi et al. (2024) used ARIMA, LSTM, and decision trees with business intelligence software to forecast financial metrics and concluded that the best predictions were provided by LSTM models with MAPE from 1.5% to 2.3%. Antwi et al. (2022) used a hybrid decomposition approach with wavelet transform, ARIMA, and machine learning models to forecast commodity futures and had a MAPE of 1.76% and RMSE of 0.092. Mgamal et al. (2023) integrated ARIMA with difference-in-difference in estimating the impact of value-added tax increases to illustrate short-run economic distortions, and patterns of recovery were accurately identified by employing ARIMA. Alshawarbeh et al. (2023) employed a hybrid model (ARIMA-ANN) in forecasting high-frequency financial time-series data and obtaining superior MAPE (1.57%) and greater accuracy prediction. Li and Zhou (2024) developed an LSTM-based model to forecast interest rates and stock prices, beating ARIMA with lower MAPE (1.23%) and RMSE, pointing out the robustness of LSTM to learn non-linear patterns.

## 4. Conclusions

Compared to other models, such as GARCH, VAR, and machine learning models, ARIMA has inherent strengths derived from its simplicity, interpretability, and capacity to capture linear interactions. While models like GARCH perform extremely well in capturing volatility and non-linearities, and machine learning models are efficient in handling complex data structures, ARIMA remains one of the best options for economic forecasting due to transparency, computational simplicity, and ease of implementation. The excellent performance of the ARIMA (2,1,1) model in this study, illustrated by an outstanding RMSE of 0.085, MAPE of 1.86%, and  $R^2$  value of 0.991, only serves to further increase its utility and applicability to forecasting interest rates in the Slovak context, particularly for short-run forecasting.

Nonetheless, the vulnerability of ARIMA must not be underestimated. Although its performance is robust, ARIMA is a linear model in nature, and, therefore, it can fall short of capturing nonlinear dynamics and structural breaks that abound in financial time series. For instance, sudden market shocks or behavioral shifts, usually brought about by external forces, may not be well reflected by ARIMA's reliance on past information and stationarity conditions. In addition, the model's focus on historic values and its differencing procedure, although essential for stationarity attainment, potentially mask long-term patterns and undermine its reaction to sudden regime changes.

These limitations show the potential for improvement in forecast models. ARIMA-based hybrid models or nonlinear approaches combined with machine learning algorithms can make the model more flexible to adjust to such complexities. These techniques can address the rigidity of ARIMA through the incorporation of adaptability and flexibility to support evolving patterns. Notably, exogenous variables in the model, such as inflation, GDP growth, and monetary policy interventions, through methods like ARIMAX, could improve the accuracy of forecasting and explanation capability of the model. The incorporation would enable the model to have a wider framework in forecasting, where it can explain the macroeconomic impacts on interest rate changes better.

The significance of this study is for Slovakia's economic policymakers and financial planners. The trend of falling interest rates, if realized, could, in the best-case scenario, create an encouraging environment to borrow and invest and hence accelerate economic growth and catalyse post-pandemic rebound. However, the uncertainty depicted in the confidence intervals necessitates conservative interpretation given the prevailing risks emanating from geopolitical instability, inflationary forces, and changing monetary policy in the EU. Because of such uncertainties, the ARIMA model offers a valuable but limited forecasting tool, and its findings have to be augmented by other models to engage in a sounder analysis.

This study contributes to the broader literature on economic forecasting by providing empirical support for the effectiveness of ARIMA in forecasting interest rates, particularly in the case of an emerging EU economy like Slovakia. It also hints at the need for a richer appreciation of the dynamics of interest rates involving both linear and non-linear aspects. Such research in the future can therefore focus on examining models that can detect and respond to structural breaks or regime shifts, which often occur under situations of economic transition. Extending the forecast horizon and accounting for a more broad-based set of economic indicators will be critical if an improved overall picture of what causes interest rates is to be obtained.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** Data sharing is not applicable to this article.

**Acknowledgments:** This paper is an output of the faculty institutional research 4/FPEDAS/2024: Analysis of the financial performance of European companies in the context of smart industry and innovation support at the Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Abounoori, E., & Tazehabadi, A. G. (2009, April). Forecasting stock price using macroeconomic variables: A hybrid ardl, arima and artificial neural network. In *2009 International Conference on Information and Financial Engineering* (pp. 149-153). IEEE. doi: 10.1109/ICIFE.2009.23
- Adebiyi, A. A., Adewumi, A. O., & Ayo, C. K. (2014). Comparison of ARIMA and artificial neural networks models for stock price prediction. *Journal of Applied Mathematics*, 2014(1), 614342. doi: 10.1155/2014/614342
- Ahmed, R. R., Vveinhardt, J., Ahmad, N., & Sreimikiene, D. (2017). Karachi inter-bank offered rate (KIBOR) forecasting: Box-Jenkins (ARIMA) testing approach. *E & M Ekonomie a management*, 20(2), 188-198. doi: 10.15240/tul/001/2017-2-014
- Alfaro, R., Becerra, S., & Sagner, A. (2011). Estimating Chile's Nominal Interest Rate Structure: An Application of the Dynamic Nelson-Siegel Model. *Economia Chilena*, 14(3), 57-74.
- Alomari, Z., Zhani, M. F., Aloqaily, M., & Bouachir, O. (2023). On ensuring full yet cost-efficient survivability of service function chains in NFV environments. *Journal of Network and Systems Management*, 31(3), 45. doi: 10.1007/s10922-023-09734-3
- Alshawarbeh, E., Abdulrahman, A. T., & Hussam, E. (2023). Statistical modeling of high frequency datasets using the ARIMA-ANN hybrid. *Mathematics*, 11(22), 4594. doi: 10.3390/math11224594
- Antwi, E., Gyamfi, E. N., Kyei, K. A., Gill, R., & Adam, A. M. (2022). Modeling and forecasting commodity futures prices: decomposition approach. *IEEE Access*, 10, 27484-27503. doi: 10.1109/ACCESS.2022.3152694
- Apley, D. W., & Shi, J. (1999). The GLRT for statistical process control of autocorrelated processes. *IIE transactions*, 31(12), 1123-1134. doi: 10.1023/A:1007692012244
- Bidarkota, P. V. (1998). The comparative forecast performance of univariate and multivariate models: an application to real interest rate forecasting. *International Journal of Forecasting*, 14(4), 457-468. doi: 10.1016/S0169-2070(98)00036-3
- Butter, F. A. D., & Jansen, P. W. (2004). An empirical analysis of the German long-term interest rate. *Applied Financial Economics*, 14(10), 731-741. doi: 10.1016/j.econmod.2017.03.031
- Canpolat, S. (2022). Modelling of the Weighted Average Funding Cost of the CBRT: LNV-ARMA Approach. *Sosyoekonomi*, 30(54), 243-256. doi: 10.17233/sosyoekonomi.2022.04.13
- Çekin, S. E., Ivashchenko, S., Gupta, R., & Lee, C. C. (2024). Real-time forecast of DSGE models with time-varying volatility in GARCH form. *International Review of Financial Analysis*, 93, 103175. doi: 10.1016/j.irfa.2024.103175
- Christo, E. S., Ferreira, M. B., & Alonso, K. C. (2013, September). Use of Statistical Control for Improved Demand Forecasting. In *2013 BRICS Congress on Computational Intelligence and 11th Brazilian Congress on Computational Intelligence* (pp. 693-698). IEEE. doi: 10.1109/BRICS-CCI-CBIC.2013.121
- Dua, P., & Pandit, B. L. (2002). Interest rate determination in India: domestic and external factors. *Journal of Policy Modeling*, 24(9), 853-875. doi: 10.1016/S0161-8938(02)00172-2
- Dua, P., Rajee, N., & Sahoo, S. (2003). *Interest rate modelling and forecasting in India*. Department of Economic Analysis and Policy, Reserve Bank of India.
- Duran, H. E., & Gajewski, P. (2023). State-level Taylor rule and monetary policy stress. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 18(1), 89-120. doi: 10.24136/eq.2023.003
- Fauvel, Y., Paquet, A., & Zimmermann, C. (1999). *A survey on interest rate forecasting* (No. 87). CREFE, Université du Québec à Montréal.
- Frajtova Michalikova, K., Imam, H., Pobee, F., & Rozhan, S. M. B. (2024). Comparative analysis of key personal traits of SME owners and managers. A perspective from business sectors. *Journal of Business Sectors*, 2(2), 40-49. doi: 10.62222/PSRV2054

- Gozgor, G. (2013). The application of stochastic processes in exchange rate forecasting: Benchmark test for the EUR/USD and the USD/TRY. *Economic Computation and Economic Cybernetics Studies and Research*, 47(2), 225-246.
- Guerrero, J., Galiano, M. D. C., & Orlando, G. (2023). Modeling COVID-19 pandemic with financial markets models: The case of Jaen (Spain). *Mathematical Biosciences and Engineering*, 20(5), 9080-9100. doi: 10.3934/mbe.2023399
- Hua, R., Hu, W., & Zhao, X. (2020). Research on RMB exchange rate forecast based on the neural network model and the Nelson–Siegel model. *Risk Management*, 22(3), 219-237. doi: 10.1057/s41283-020-00062-3
- Hubik, V. (2024). Introducing Islamic Banking in the Czech Republic: A Customer Perspective Study. *Journal of Business Sectors*, 2(2), 73–81. doi: 10.62222/ALAK1693
- Kolkova, A., & Rozehnal, P. (2022). Hybrid demand forecasting models: pre-pandemic and pandemic use studies. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 17(3), 699-725. doi: 10.24136/eq.2022.024
- Kozuch, A., Cywicka, D., & Adamowicz, K. (2023). A comparison of artificial neural network and time series models for timber price forecasting. *Forests*, 14(2), 177. doi: 10.3390/f14020177
- Krishnan, J., Money, R., Beferull-Lozano, B., & Isufi, E. (2024). Simplicial vector autoregressive models. *IEEE Transactions on Signal Processing*, 72, 5454-5469. doi: 10.1109/TSP.2024.3503063
- Kumar, K. A., Spulbar, C., Pinto, P., Hawaldar, I. T., Birau, R., & Joisa, J. (2022). Using econometric models to manage the price risk of cocoa beans: A case from India. *Risks*, 10(6), 115. doi: 10.3390/risks10060115
- Kumar, P. B., & Hariharan, K. (2022). Time series traffic flow prediction with hyper-parameter optimized ARIMA models for intelligent transportation system. *Journal of Scientific & Industrial Research*, 81(04), 408-415.
- Kumar, S. V., & Vanajakshi, L. (2015). Short-term traffic flow prediction using seasonal ARIMA model with limited input data. *European Transport Research Review*, 7(3), 21. doi: 10.1007/s12544-015-0170-8
- Li, K., & Zhou, Y. (2024). Improved financial predicting method based on time series long short-term memory algorithm. *Mathematics*, 12(7), 1074. doi: 10.3390/math12071074
- Liang, F., Zhang, H., & Fang, Y. (2022). The analysis of global RMB exchange rate forecasting and risk early warning using ARIMA and CNN model. *Journal of Organizational and End User Computing*, 34(8), 1-25. doi: 10.4018/JOEUC.300762
- Makika, H., Romano, J. M. T., & Ballini, R. (2023, September). Deep Learning Techniques for Time Series Forecasting: An Application for Exchange Rates. In *2023 IEEE 33rd International Workshop on Machine Learning for Signal Processing* (pp. 1-6). IEEE.
- Mallick, A. K., & Mishra, A. K. (2019). Interest rates forecasting and stress testing in India: a PCA-ARIMA approach. *Palgrave Communications*, 5, 32. doi: 10.1057/s41599-019-0236-7
- Mgammal, M. H., Al-Matari, E. M., & Alruwaili, T. F. (2023). Value-added-tax rate increases: A comparative study using difference-in-difference with an ARIMA modeling approach. *Humanities and Social Sciences Communications*, 10(1), 1-17. doi: 10.1057/s41599-023-01608-y
- National Bank of Slovakia. (n.d.). *Priemerne urokovie miery z uverov bank*. <https://nbs.sk/statisticke-udaje/financne-trhy/urokovie-sadzby/priemerne-urokovie-miery-z-uverov-bank/>
- Noorunnahar, M., Chowdhury, A. H., & Mila, F. A. (2023). A tree based eXtreme Gradient Boosting (XGBoost) machine learning model to forecast the annual rice production in Bangladesh. *PloS one*, 18(3), e0283452. doi: 10.1371/journal.pone.0283452
- Paik, J., & Ko, K. (2024). Seasonal Analysis and Risk Management Strategies for Credit Guarantee Funds: A Case Study from Republic of Korea. *Stats*, 8(1), 2. doi: 10.3390/stats8010002
- Pang, Y. H., Wang, H. B., Zhao, J. J., & Shang, D. Y. (2020). Analysis and prediction of hydraulic support load based on time series data modeling. *Geofluids*, 2020(1), 8851475. doi: 10.1155/2020/8851475
- Rajab, K., Kamalov, F., & Cherukuri, A. K. (2022). Forecasting COVID-19: vector autoregression-based model. *Arabian journal for science and engineering*, 47(6), 6851-6860. doi: 10.1007/s13369-021-06526-2
- Ray, S., Lama, A., Mishra, P., Biswas, T., Das, S. S., & Gurung, B. (2023). An ARIMA-LSTM model for predicting volatile agricultural price series with random forest technique. *Applied Soft Computing*, 149, 110939. doi: 10.1016/j.asoc.2023.110939
- Rezaei, R., & Shabri, A. (2024). An innovative hybrid W-EEMD-ARIMA model for drought forecasting using the standardized precipitation index. *Natural Hazards*, 120(14), 13513-13542. doi: 10.1007/s11069-024-06758-z
- Shen, M. L., Lee, C. F., Liu, H. H., Chang, P. Y., & Yang, C. H. (2021). Effective multinational trade forecasting using LSTM recurrent neural network. *Expert Systems with Applications*, 182, 115199. doi: 10.1016/j.eswa.204.115199
- Tang, D. (2023, May). Optimization of Financial Market Forecasting Model Based on Machine Learning Algorithm. In *2023 International Conference on Networking, Informatics and Computing* (pp. 473-476). IEEE.

- Tarmanini, C., Sarma, N., Gezegin, C., & Ozgonenel, O. (2023). Short term load forecasting based on ARIMA and ANN approaches. *Energy Reports*, 9, 550-557. doi: 10.1016/j.egyr.2023.01.060
- Udoeye, A., Akinola, L., & Ogbaji, E. (2020). Extension of Vasicek Model to the Modelling of Interest Rate. *Fudma Journal of Sciences*, 4(2), 151-155.
- Wang, S. (2008). Evaluating the Forecast of ARIMA Models Based on Statistical Methods. *Recent advance in statistics application and related areas*, 1(2), 450-453.
- Xiao, C., & Pang, B. (2017, December). Impact of anticipated and unanticipated monetary policy on real estate market: a study based on SVAR model. In *3rd International Conference on Economics, Management, Law and Education* (pp. 174-180). Atlantis Press.
- Xie, Y., Jin, M., Zou, Z., Xu, G., Feng, D., Liu, W., & Long, D. (2020). Real-time prediction of docker container resource load based on a hybrid model of ARIMA and triple exponential smoothing. *IEEE Transactions on Cloud Computing*, 10(2), 1386-1401. doi: 10.1109/TCC.2020.2989631
- Yamacli, D. S., & Yamacli, S. (2023). Estimation of the unemployment rate in Turkey: A comparison of the ARIMA and machine learning models including Covid-19 pandemic periods. *Heliyon*, 9(1), e12796. doi: 10.1016/j.heliyon.2023.e12796
- Yasir, M., Afzal, S., Latif, K., Chaudhary, G. M., Malik, N. Y., Shahzad, F., & Song, O. Y. (2020). An efficient deep learning based model to predict interest rate using twitter sentiment. *Sustainability*, 12(4), 1660. doi: 10.3390/su12041660
- Zasadnyi, B., Mykhalska, O., & Kyrillov, O. (2024). Using Business Intelligence Tools in the Process of Forecasting a Company's Financial Indicators. *Financial and Credit Activity-Problems of Theory and Practice*, 1(54), 244-259. doi: 10.55643/fcaptp.1.54.2024.4240

# INVISIBLE CAPITAL AT WORK: EVALUATING THE IMPACT OF INTANGIBLE ASSETS ON COMPANY PERFORMANCE

Marcel Figura<sup>1,a,\*</sup> and Oana-Matilda Sabie<sup>2,b</sup>

<sup>1</sup>University of Zilina, Faculty of Operation and Economics of Transport and Communications,  
Department of Economics, Univerzitna 1, 010 26 Zilina, Slovakia

<sup>2</sup>Bucharest University of Economic Studies, Administration and Public Management Faculty,  
Department of Administration and Public Management, 6 Piata Romana, 1st district, 010374

Bucharest, Romania

<sup>a</sup>marcel.figura@stud.uniza.sk, <sup>b</sup>oana.sabie@amp.ase.ro

\*Corresponding author

**Cite as:** Figura, M., Sabie, O.M. (2025). *Invisible Capital at Work: Evaluating the Impact of Intangible Assets on Company Performance*, *Ekonomicko-manazerske spektrum*, 19(1), 14-27.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.14-27](https://dx.doi.org/10.26552/ems.2025.1.14-27)

---

*Received: 30 November 2024; Received in revised form: 23 February 2025; Accepted: 5 March 2025; Available online: 30 June 2025*

## **Abstract:**

**Research background:** The increasing role of intangible assets in the digital economy is significantly transforming business structures in Europe. While the relevance of assets such as software, patents, or know-how is growing, their impact on company performance remains underexplored, particularly in Central and Eastern European countries. Gaps persist in understanding how intangible assets contribute to revenue generation and profit creation across company sizes and national contexts.

**Purpose of the article:** The aim of this article is to analyse the evolution and financial implications of intangible assets in manufacturing companies operating in Slovakia and the Czech Republic. The research investigates the relative importance of intangible versus tangible assets and compares their influence on key performance indicators such as operating revenue and operating profit, with a specific focus on size-based differences.

**Methods:** The analysis is based on data from the years 2018 to 2023, covering a sample of 1,393 manufacturing companies from the ORBIS database. The analysis combines descriptive statistics, year-on-year growth comparisons through paired samples t-tests, Spearman correlation analysis and separate linear regression models for each country.

**Findings & Value added:** The results show that intangible assets are growing faster than total assets, especially in Slovak SMEs and very large companies. While correlations with financial performance are statistically significant, they remain moderate in strength. Regression models explain over 98 percent of revenue variability and confirm the economic relevance of intangible assets, which outperform tangible ones in predictive value. The value added of this study lies in confirming the role of intangible assets as a relevant but not standalone factor in financial performance.

**Keywords:** intangible; performance; manufacturing sector; empirical research; digitalisation

**JEL Classification:** M21; O34; L25

## **1. Introduction**

The dynamic development of the digital economy and the increasing importance of the knowledge-based economy are leading businesses in Europe to make fundamental changes in the structure of their assets. The traditional emphasis on tangible assets is gradually being replaced by the growing importance of intangible assets, which include software, patents, data, organisational capabilities or human capital. Despite this shift, intangible assets remain partially undervalued in many analytical models. This is mainly due to the fact that its impact on company performance is not always grasped in a consistent way, while at the same time, its systematic measurement and comparison across countries or sectors is often lacking. Given these challenges, there is a need to verify to what extent the evolution of intangible assets is reflected in company performance and what role it plays in the current digital transformation. This study therefore intends to analyse the development of intangible assets in companies in the Slovak and Czech Republics, compare it with the development of total assets and examine its relationship with revenue and profitability.

The growth of investment in intangible assets is confirmed by a number of empirical studies showing its positive impact on company performance. In their analysis, Roth et al. (2022) identify a strong link between the level of intangible assets and companies' financial performance, arguing that it is one of the main sources of sustainable growth. Antzoulatos et al. (2022) point out that despite existing differences across countries, convergence in the perception and use of intangible assets can be observed. These findings are consistent with a study by Chen (2018), who shows that productivity differences across countries can be significantly explained by differences in the intensity of investment in intangibles. Corrado et al. (2017) add that knowledge-intensive and R&D-orientated sectors exhibit the highest levels of investment, which also leads to higher innovation capacity and adaptability to technological change.

Important insights on structural differences emerge when analysing the central and eastern European regions. As suggested by several research sources, the growth of intangible assets in countries such as Slovakia or the Czech Republic may be mainly influenced by external impulses, for example, through integration into global value chains and the presence of multinational owners (Durcova and Pekarcik, 2023; Thum-Thysen, 2017; Van Assche, 2020). These findings are confirmed by the McKinsey Global Institute (2021) report, which warns of the risk of over-dependence on external sources of know-how and insufficient internal innovation creation. These conditions are causing intangible assets to become the preserve of larger or foreign companies in some countries, while small and medium-sized enterprises (SMEs) face constraints in building and capitalising on them. Svarc et al. (2020) point out that regional differences in the use of intangible assets are closely related to the quality of the business environment, the availability of digital infrastructure and the level of collaboration between research and business.

Intangible assets should not be seen as passive assets but as active inputs to the process of business transformation. Nagy et al. (2023) and Juracka et al. (2024) describe how companies are moving towards digital architecture-based models where algorithms, data, analytics and know-how are key elements of value. In this sense, intangible assets are not only the result of innovation but also a precondition for it. From this perspective, it plays an important role in a company's ability to implement advanced technologies such as artificial intelligence. Corrado et al. (2021) confirm that artificial intelligence adoption is more successful in companies that already have a strong base of intangible capital. Belloc and Valentini (2024) add that it is investment in intangible assets that allows companies to reduce the technology gap and more effectively counter the disruptions caused by automation. A similar view is held by the

McKinsey Global Institute (2021), which argues that companies with a higher share of intangible assets are not only more efficient but also more resilient to economic shocks and more able to adapt to rapid technological change.

Even in academic circles outside the European context, intangible assets are considered a strategic resource. According to Haskel and Westlake (2018), intangible assets represent a new type of capital that replaces physical infrastructure as the main engine of growth in the twenty-first century. Similarly, Brynjolfsson and McAfee (2016) argue that in the age of digital technology, value is created primarily through knowledge, software and networks, rather than through traditional factors of production. From this perspective, intangible assets can be seen as drivers of so-called invisible capital, the impact of which is often more perceptible than any physical input.

However, intangible assets are not evenly distributed across all companies or sectors. As Gumbau-Albert (2023) points out, regional differences in the use of intangible assets reflect not only the degree of innovative activity but also differences in the absorptive capacity of companies and their ability to implement knowledge in economic practice. Corrado et al. (2021) add that the ability to transform intangible assets into performance depends on the extent to which these assets are integrated into business strategies and processes. High levels of organisational capital, analytical skills and know-how enhance the effective use of intangible assets and increase their impact on performance. At the same time, in less developed regions and in small businesses, these assets are often used inefficiently or go unnoticed in traditional metrics for assessing corporate growth (Van Criekingen et al., 2021).

Research by Kafouros and Aliyev (2015) and Stan et al. (2024) reveals that companies in transition economies can gain a competitive advantage precisely by investing in intangible assets that allow for a more flexible response to changing market conditions. Labunska et al. (2024) also show that the regulatory environment, particularly in the area of intellectual property rights, affects the extent to which companies are willing to invest in intangible assets. These factors are particularly relevant for Central Europe, where the legal and innovation infrastructure is often fragmented (Ulnicane, 2020).

A review of the literature suggests that intangible assets are a deciding factor in modern company performance. At the same time, however, there remains a knowledge deficit, especially for SMEs and for Central European countries where data are not as widely available. This study therefore makes a relevant contribution not only by quantifying year-on-year changes in intangible assets but also by comparing them with the evolution of total assets and analysing their relationship with revenue and profit. The analysis focuses specifically on companies operating in NACE Section C, i.e., in the manufacturing industry, thus ensuring sectoral consistency and the possibility to take into account the specificities of the manufacturing economy. The focus on Slovakia and the Czech Republic also allows for verifying to what extent the conclusions from Western studies are applicable in smaller economies and what specificities these regions exhibit. The results can contribute to a better understanding of economic dynamics in times of digital transformation and at the same time serve as a basis for the design of policies supporting the growth of intangible investments.

## **2. Methodology**

The aim of this study is to examine the development of intangible assets in companies in the manufacturing sector in Slovakia (SK) and the Czech Republic (CZ) and also to assess its relationship with the performance indicators of companies. Particular attention is paid to the comparison between different size categories of companies, as well as to the identification of

differences between the two countries under study. The analysis is based on data from the international ORBIS database, which provides detailed economic information on companies operating in different sectors and countries. For the purpose of this study, only companies classified according to the NACE Rev. 2 industry C – Manufacturing were selected from the database. The sampling frame included companies from the Czech and Slovak Republics that had available and non-absent data in the variables under study for the years 2018 to 2023. An overview of the variables used, including their units of measurement, is presented in Table 1. After applying the selected variables, the sample consisted of 715 Czech and 678 Slovak companies, which were further divided into size categories. In the Czech Republic, there were 132 small and medium-sized enterprises (SMEs), 360 companies classified as large companies and 223 very large companies. In the case of Slovakia, 137 companies were classified as SMEs, 346 were large companies and 195 were very large companies. The size classification was drawn directly from data available in the ORBIS database, which classifies companies according to a combination of several indicators, such as number of employees, turnover and balance sheet total assets.

*Table 1: Overview of variables and measurement units*

| <b>Variable</b>              | <b>Unit of Measurement/Type</b>                 |
|------------------------------|-------------------------------------------------|
| Intangible assets            | th. EUR                                         |
| Tangible fixed assets        | th. EUR                                         |
| Total assets                 | th. EUR                                         |
| Operating revenue (turnover) | th. EUR                                         |
| Operating profit (EBIT)      | th. EUR                                         |
| Cost of goods sold           | th. EUR                                         |
| Country                      | Categorical ( <i>Slovakia, Czech Republic</i> ) |
| Size classification          | Categorical ( <i>SME, Large, Very large</i> )   |

*Source: own processing*

The analysis is designed in several steps, starting with descriptive statistics to capture the underlying trends in the level of intangible assets across size categories and between the two countries. As part of this phase, the share of intangible assets in total assets was also quantified, allowing an assessment not only of the absolute level but also of the relative importance of this type of asset within the overall asset structure of companies. This approach provided an initial picture of the extent to which intangible assets play a role in companies of different sizes and in different national contexts.

The second part of the analysis proceeded to compute the year-on-year relative changes in intangible assets and total assets. These values then formed the basis for the application of a paired samples T-test, which was used to test for the existence of statistically significant differences between the growth of intangible assets and the growth of total assets. The tests were carried out separately for each country and size category in order to capture the specificities in the dynamics of development depending on the size of the company and the economic environment.

This phase was followed by a correlation analysis in which Spearman's correlation coefficients were calculated between the level of intangible assets and the performance variables, namely operating revenue (turnover) and operating profit (EBIT). The correlations were found separately for Slovak and Czech companies, which allowed for a comparison of the relationships between asset structure and performance in the context of national differences. This step was important for understanding whether a higher share of intangible assets in companies is related to their better performance.

In the last part of the methodological framework, a linear regression analysis was conducted to quantify the impact of intangible assets on companies' operating revenue (turnover).

Intangible assets and tangible assets were included as explanatory variables in the model. To capture differences between size categories, dummy variables representing the categories of SMEs and large companies were also included in the model, with very large companies as the reference category. Regression models were constructed separately for Slovakia and the Czech Republic. The control procedure also included the verification of multicollinearity through the VIF (Variance Inflation Factor) value. The results were interpreted on the basis of unstandardised B coefficients for the main economic variables and standardised beta coefficients for the remaining explanatory variables. Precisely in this way, it was possible to quantify the average impact of the growth of intangible and tangible assets on the performance indicators while capturing the significance of differences between companies of different size categories.

All the calculations, tests and visualisations were carried out in the IBM SPSS Statistics 27 software. This software provided the space to efficiently process a large sample set and also allowed the statistical testing to be combined with the interpretation of the effect sizes. The significance of the results was assessed at a p-value level  $< 0.05$ .

### **3. Results**

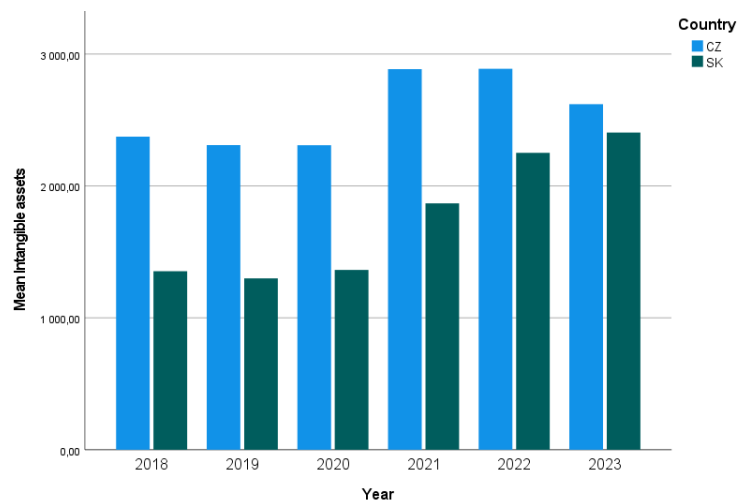
#### **3.1. Descriptive statistics**

The clustered bar chart provides an overview of the evolution of the average volumes of intangible assets in companies operating in Slovakia and the Czech Republic over the period 2018 to 2023. The visualisation in Figure 1 includes all size categories of companies, including SMEs, large companies and very large companies. The figure reveals that Czech companies had a higher average volume of intangible assets than Slovak companies in each of the years studied. Between 2018 and 2020, Czech companies remained relatively stable at a level just above EUR 2,300 thousand, while Slovak companies recorded lower values in the range of approximately EUR 1,400 to 1,500 thousand in the same period. A more significant change occurred in 2021, when the average intangible assets of Czech companies increased to almost EUR 2,900 thousand, and this level was maintained in 2022. A drop in the average volume of intangible assets was observed in the Czech Republic in 2023, falling below EUR 2,700 thousand, which still represents a higher value than in the initial three years. In contrast, Slovak companies have seen a steady increase since 2021. From around EUR 1,900 thousand in 2021 to over EUR 2,400 thousand in 2023, narrowing the gap with Czech companies.

In terms of a comparison of developments between countries, it can be noted that while the Czech Republic has maintained a steadily higher level of average intangible assets throughout the period, Slovakia has seen a more pronounced growth, especially in the second half of the period under review. This shift may indicate a later activation of investment activities related to digitalisation, R&D or innovation in Slovak companies. It is also important to note that while the gap between countries was quite significant between 2018 and 2020, the gap has narrowed in recent years. The smallest difference between countries was observed in 2023, which may indicate some convergence in the way and intensity of the use of intangible assets in business practice. The results thus suggest that Slovak companies are catching up with Czech companies in recent years in terms of investment in intangible assets, which may have a positive long-term impact on their competitiveness and technological maturity.

The multi-panel line chart in Figure 2 enables a more detailed observation of the dynamics of the development of the average volume of intangible assets between 2018 and 2023, taking into account the size category of companies and their country of origin. Whereas in the previous

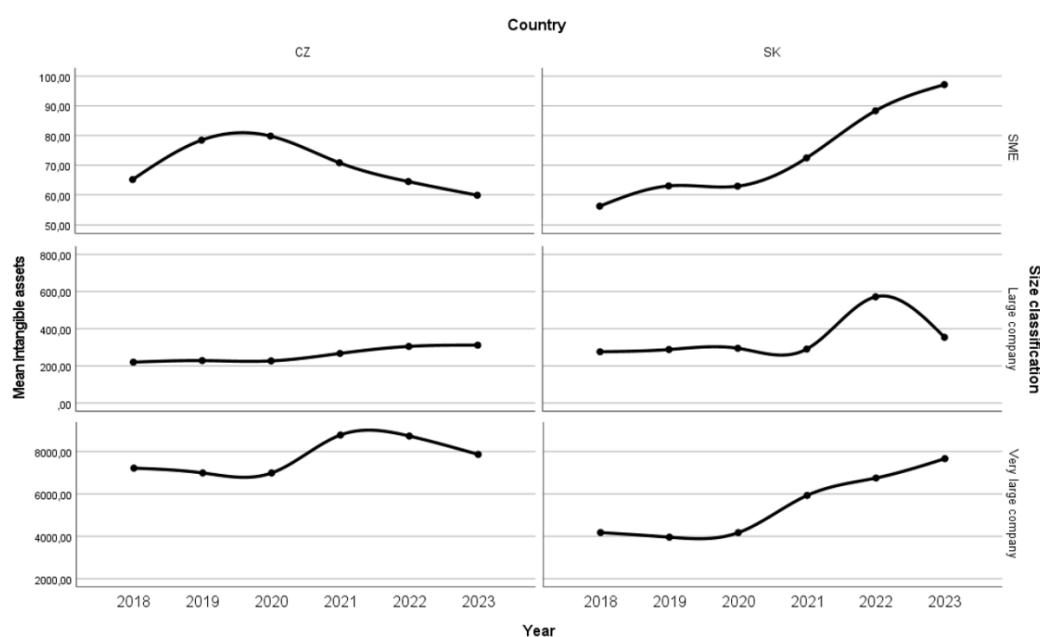
Figure 1: Evolution of average intangible assets by year



Source: own processing

visualisation all companies were aggregated, this chart reveals more pronounced differences between size categories that would otherwise remain hidden. In general, very large companies have the highest average intangible asset values regardless of country, with Slovak companies in this category showing a steadily increasing trend since 2020. Between 2018 and 2020, Slovak very large companies were steadily below EUR 5,000 thousand, but from 2021 onwards they started to show a rapid increase, culminating in 2023 at a value of almost EUR 8,000 thousand. The Czech development in this category is smoother, with a gentle decline until 2020, followed by a sharp increase in 2021 and 2022 and a slight decline in 2023. Despite the smaller dynamics, the average in the Czech Republic remains higher than in Slovakia only during the first few years, with very large Slovak companies reaching a comparable level in 2023.

Figure 2: Development of average intangible assets by company size and country (2018–2023)



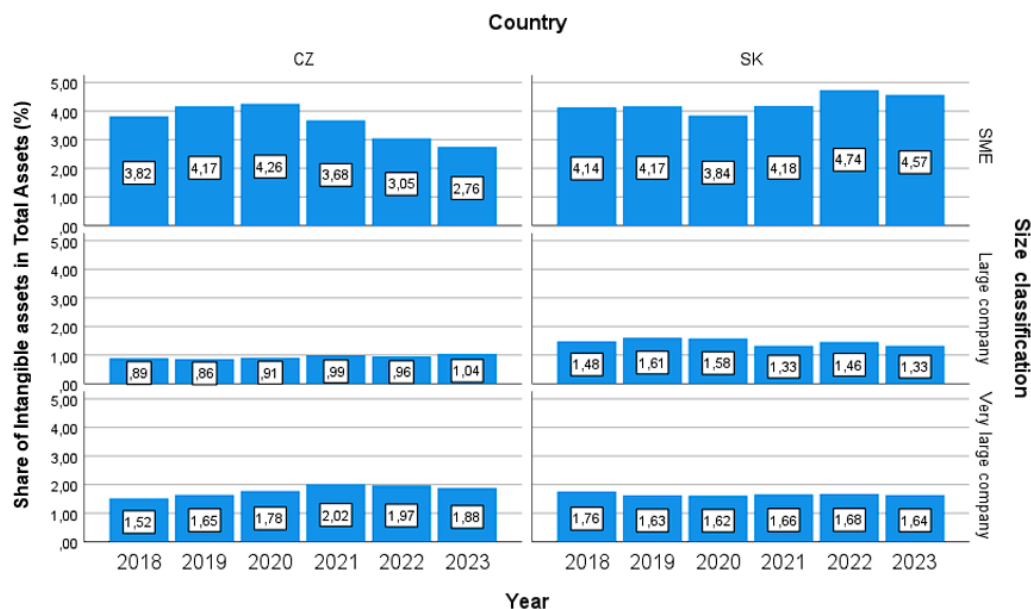
Source: own processing

An interesting contrast can also be observed in the SMEs category. In the Czech Republic, these companies had the highest level of intangible assets in 2019 and 2020, but there was a

slight decline thereafter, which disrupted the previously upward trend. In contrast, Slovak SMEs show a consistent increase throughout the period under review. From just under EUR 60 thousand in 2018 to almost EUR 100 thousand in 2023, outperforming Czech companies in this category in the final years. In the large company category, the course of development in both countries is largely stable. In the Czech Republic, the average intangible asset values are in a relatively narrow band between EUR 270 and 350 thousand, with a gradual increase appearing especially after 2020. Slovak large companies show slightly higher volatility, an upward trend until 2022, which is then disrupted by a decline in 2023. Based on these trends, it can be stated that Slovak companies, especially in the categories of SMEs and very large companies, have shown a stronger propensity to invest in intangible assets in recent years. This shift may indicate an increased focus on strengthening innovation and technology investments in response to trends observed in the Czech Republic.

The graph in Figure 3 presents the evolution of the average share of intangible assets in the total assets of companies over the period 2018 to 2023, distinguishing between countries as well as between size categories of companies. This indicator is particularly informative, as it helps identify the extent to which intangible assets constitute a structurally significant component of total assets. The previous graphs showed the evolution of the absolute values of intangible assets and pointed to their dynamic growth, especially in the case of Slovak SMEs and very large companies. This graph provides a complementary view on whether this growth has also corresponded to a strengthening of the relative weight of intangible assets in total assets. The trend shown suggests that despite the increase in absolute values, the proportional importance of intangible assets has not increased evenly across categories and in some cases has remained stable or even declined.

Figure 3: Average share of intangible assets in the capital structure of companies by size category



Source: own processing

Slovak SMEs recorded the highest share growth dynamics, reaching the highest values of all analysed categories from 2020 onwards. Their share of intangible assets in total assets stabilised above 4.5 percent, significantly exceeding the levels observed for Czech SMEs. In the Czech Republic, the share decreased from a peak of around 4.3 percent after 2020 to approximately 2.8 percent in 2023. This difference may reflect variation in investment orientation, the level of

digital readiness or financial reporting methodology. In the case of large companies, the shares in both countries are significantly lower, around 1 percent, with Slovak large companies even showing a slight decline. Very large companies exhibit slightly higher shares, around 1.6 to 2 percent, but their development remains relatively stable with minimal fluctuations. These findings suggest that an increase in intangible assets in absolute terms may not automatically be accompanied by an increase in their structural significance. A proper understanding of the role of intangible assets therefore requires parallel monitoring of both their volume and their relative share in total assets.

### 3.2. Paired samples T-tests

The results of the Paired Samples T-test for Slovak companies (Table 2) clearly show a systematic difference between the growth of intangible assets and the growth of total assets across all size categories. In the case of SMEs, the average annual growth of intangible assets reached 53.55 percent, while total assets grew by only 5.14 percent. The average difference of 48.41 percentage points between these two growth types was statistically significant ( $p\text{-value} = 0.0160$ ). An even more pronounced difference was observed among large companies, where intangible assets grew by 148.99 percent compared to only 8.14 percent in total assets, resulting in an average difference of 140.85 percentage points, which was statistically significant ( $p\text{-value} < 0.0010$ ). For very large companies, the difference was again substantial, with intangible asset growth reaching 177.46 percent and total asset growth at just 8.80 percent. The resulting difference of 168.66 percentage points was statistically significant ( $p\text{-value} = 0.0110$ ).

Table 2: Summary of Paired Samples T-test results and effect sizes for Slovak companies by size category

| Paired Samples Statistics   |                          |           |                |                 |
|-----------------------------|--------------------------|-----------|----------------|-----------------|
|                             |                          | Mean      | Std. Deviation | Std. Error Mean |
| SME                         | growth intangible assets | 53.5534   | 529.3615       | 20.2259         |
|                             | growth total assets      | 5.1411    | 26.3678        | 1.0075          |
| Large company               | growth intangible assets | 148.9903  | 1,473.0074     | 35.4147         |
|                             | growth total assets      | 8.1364    | 26.0291        | 0.6258          |
| Very large company          | growth intangible assets | 177.4562  | 2,078.2376     | 66.5569         |
|                             | growth total assets      | 8.8007    | 28.6258        | 0.9168          |
| Paired Samples Test         |                          |           |                |                 |
|                             |                          | Mean      | Std. Deviation | Sig. (2-tailed) |
| SME                         | growth intangible assets | 48.4122   | 525.5936       | 0.0160          |
| Large company               | – growth total assets    | 140.8539  | 1,468.0014     | <0.0010         |
| Very large company          |                          | 168.6555  | 2,077.139      | 0.0110          |
| Paired Samples Effect Sizes |                          |           |                |                 |
|                             |                          |           | Standardizer   | Point Estimate  |
| SME                         | growth intangible assets | Cohen's d | 525.5936       | 0.0920          |
| Large company               | – growth total assets    |           | 1,468.0014     | 0.0960          |
| Very large company          |                          |           | 2,077.9393     | 0.0810          |

Source: own processing

Although all differences were statistically significant, effect sizes based on Cohen's  $d$  indicate a relatively low level of practical significance, ranging from 0.0810 to 0.0960. This outcome is primarily due to high variability in the data on intangible asset growth, which is also reflected in large standard deviations. Nevertheless, these findings provide a relevant insight. The growth of intangible assets substantially exceeds the growth of total assets across all categories of Slovak companies, indicating a specific investment dynamic in intangible resources. The fact that this difference was observed across the entire size spectrum may suggest a broader trend in which companies systematically strengthen their know-how, software capacities, or other forms of intangible capital independently of overall asset growth.

The results for the Czech Republic (Table 3), based on paired samples t-tests comparing the growth of intangible and total assets, also reveal notable differences across company size categories. Among SMEs, intangible assets showed a markedly higher average growth value of 158.77 percent compared to 7.22 percent for total assets. However, due to extremely high variability in the data, as evidenced by a standard deviation of over 2400, the difference was not statistically significant. The p-value reached 0.1090, and the effect size, expressed as Cohen's d, was 0.0620, indicating only a negligible practical difference. These findings suggest the absence of a consistent pattern and point rather to diverse investment behaviour within this group than to a systematic tendency toward higher intangible asset growth.

*Table 3: Summary of Paired Samples T-test results and effect sizes for Czech companies by size category*

| <b>Paired Samples Statistics</b>   |                          | Mean      | Std. Deviation | Std. Error Mean |
|------------------------------------|--------------------------|-----------|----------------|-----------------|
| SME                                | growth intangible assets | 158.7659  | 2,425.2254     | 94.4018         |
|                                    | growth total assets      | 7.2182    | 38.1974        | 1.4868          |
| Large company                      | growth intangible assets | 106.7919  | 985.9231       | 23.2384         |
|                                    | growth total assets      | 6.8314    | 20.6088        | 0.4858          |
| Very large company                 | growth intangible assets | 121.2538  | 979.2816       | 29.3272         |
|                                    | growth total assets      | 6.9668    | 19.5749        | 0.5862          |
| <b>Paired Samples Test</b>         |                          | Mean      | Std. Deviation | Sig. (2-tailed) |
| SME                                | growth intangible assets | 151.5477  | 2,425.5693     | 0.1090          |
| Large company                      | – growth total assets    | 99.9605   | 984.9090       | <0.0010         |
| Very large company                 |                          | 114.2870  | 977.8220       | <0.0010         |
| <b>Paired Samples Effect Sizes</b> |                          |           | Standardizer   | Point Estimate  |
| SME                                | growth intangible assets | Cohen's d | 2,425.5693     | 0.0620          |
| Large company                      | – growth total assets    |           | 984.9090       | 0.1010          |
| Very large company                 |                          |           | 977.8220       | 0.1170          |

*Source: own processing*

In contrast, the results for larger companies confirm a statistically significant difference in both categories. For large companies, the average difference between intangible and total asset growth reached 99.96 percentage points with a p-value below 0.0010. Among very large companies, the average difference was 114.23 percentage points, also statistically significant with a p-value below 0.0010. Despite small effect sizes of 0.1010 and 0.1170, the consistency of the results and the size of the samples indicate a stable pattern. Compared to Slovakia, the most notable contrast is the lack of significance in the SMEs category, which in Slovakia showed a clear difference in favour of intangible assets. This contrast may reflect differing investment priorities and resource allocation strategies among smaller companies in both countries, even though the absolute growth values for intangible assets were substantially higher in both cases. The overall results indicate that in Czech companies the tendency for intangible asset growth to exceed total asset growth becomes more systematic with increasing company size.

### 3.3. Correlation analysis

The results of the Spearman correlation between the value of intangible assets and the core performance indicators of companies, specifically operating revenue and operating profit, suggest that there is a statistically significant but only moderately strong association between these variables in both the Slovak and Czech contexts. Among Slovak companies, the correlation coefficient (Table 4) between intangible assets and operating revenue reached 0.465 with a p-value below 0.001, which indicates a moderate relationship. The correlation with operating profit was lower at 0.293 but remained statistically significant. These results may be

interpreted as evidence that companies with a higher level of investment in intangible assets such as software solutions, patents, brands or know-how generally achieve higher revenues. The relationship with operating profit is present to a lesser extent, which may be related to the fact that intangible assets primarily support operating revenue growth, while their effect on operating profit may be moderated by other cost-related factors.

*Table 4: Correlation between intangible assets and performance indicators (Slovak companies)*

| Spearman's rho | Intangible assets |                 | Operating revenue       | Operating profit        |
|----------------|-------------------|-----------------|-------------------------|-------------------------|
|                |                   |                 | Correlation Coefficient | Correlation Coefficient |
|                |                   |                 | 0.465                   | 0.293                   |
|                |                   | Sig. (2-tailed) | <0.001                  | <0.001                  |
|                |                   | N               | 678                     | 678                     |

*Source: own processing*

In the Czech sample, the values of the correlation coefficients (Table 5) were similar or slightly higher, which may indicate a somewhat stronger link between intangible assets and company performance. The correlation between intangible assets and operating revenue reached 0.521 (p-value < 0,001), representing the upper bound of a moderate association. The relationship with operating profit was weaker at 0.320, yet again statistically significant (p-value < 0,001). This slightly stronger correlation may result from more consistent or systematic reporting of intangible assets or from greater efficiency in their use to generate revenue. Nevertheless, in neither country do these correlations reach high levels, which indicates that intangible assets are only one of several factors influencing company performance. Their effects are likely exercised in combination with other organisational, industry-specific and macroeconomic variables. The findings therefore confirm the role of intangible assets as a partial determinant of revenue and profit performance while also highlighting the need for a deeper analysis of their synergies with other drivers of business outcomes.

*Table 5: Correlation between intangible assets and performance indicators (Czech companies)*

| Spearman's rho | Intangible assets |                 | Operating revenue       | Operating profit        |
|----------------|-------------------|-----------------|-------------------------|-------------------------|
|                |                   |                 | Correlation Coefficient | Correlation Coefficient |
|                |                   |                 | 0.521                   | 0.320                   |
|                |                   | Sig. (2-tailed) | <0.001                  | <0.001                  |
|                |                   | N               | 715                     | 715                     |

*Source: own processing*

### 3.4. Linear regression analysis

The regression model for the Slovak Republic (Table 6) explains the variability in company operating revenues based on selected asset components, cost structure and size classification. The model demonstrates an exceptionally high level of explained variance with an adjusted  $R^2$  value of 0.997, indicating that the explanatory variables account for nearly all variability in the dependent variable. All predictors are statistically significant at the p-value level below 0.001, confirming their relevance within the model. Since size classification was introduced through two dummy variables, the reference category in this case is represented by very large companies.

In terms of quantitative impact, the unstandardised coefficients show that an increase in intangible assets by one thousand euros is associated with an average increase in operating revenue of 1,273 euros, assuming all other variables remain constant. While this effect appears relatively low in comparison with other factors, it offers some indication of the economic return on intangible investments. In contrast, tangible fixed assets show an even smaller effect, with an increase of one thousand euros leading to an average operating revenue increase of 323 euros, suggesting a weaker direct link between physical infrastructure and company

Table 6: Linear regression results for the Slovak Republic (dependent variable: Operating revenue)

| Variable                            | Unstandardised<br>B | Standardised<br>Beta | Sig.   | VIF   | R <sup>2</sup> | Adjusted<br>R <sup>2</sup> | Sig.<br>(Anova) |
|-------------------------------------|---------------------|----------------------|--------|-------|----------------|----------------------------|-----------------|
| Constant                            | 25,934.030          |                      | <0.001 |       | 0.998          | 0.997                      | <0.001          |
| Intangible assets                   | 1.273               | 0.042                | <0.001 | 1.185 |                |                            |                 |
| Cost of goods sold                  | 1.581               | 0.941                | <0.001 | 2.495 |                |                            |                 |
| Tangible fixed asset                | 0.323               | 0.054                | <0.001 | 2.864 |                |                            |                 |
| Size classification = SME           | -25,684.230         | -0.016               | <0.001 | 1.478 |                |                            |                 |
| Size classification = Large company | -19,996.287         | -0.015               | <0.001 | 1.508 |                |                            |                 |

Source: own processing

performance in this model. Among the remaining predictors, cost of goods sold stands out with the highest standardised coefficient of 0.941, confirming its key role in determining operating revenue levels. The negative coefficients for the dummy variables representing SMEs and large companies indicate that these categories report lower average operating revenues compared to the reference category of the very large companies.

Lastly, the Variance Inflation Factor (VIF) for all predictors remains below value 3, indicating the absence of multicollinearity in the model and confirming that the individual variables do not contribute redundant information. This strengthens the credibility and stability of the regression model.

The regression model for the Czech Republic also achieves a high level of explained variability, with an adjusted R<sup>2</sup> value of 0.987. All predictors are statistically significant at the p-value level below 0.001, indicating their relevance for explaining company operating revenues. The structure of the model, including the use of dummy variables for company size, remains consistent with the approach applied to the Slovak sample, where very large companies serve as the reference category.

Table 7: Linear regression results for the Czech Republic (dependent variable: Operating revenue)

| Variable                            | Unstandardised<br>B | Standardised<br>Beta | Sig.   | VIF   | R <sup>2</sup> | Adjusted<br>R <sup>2</sup> | Sig.<br>(Anova) |
|-------------------------------------|---------------------|----------------------|--------|-------|----------------|----------------------------|-----------------|
| Constant                            | 26,980.681          |                      | <0.001 |       | 0.994          | 0.987                      | <0.001          |
| Intangible assets                   | 1.347               | 0.035                | <0.001 | 1.109 |                |                            |                 |
| Cost of goods sold                  | 1.695               | 0.957                | <0.001 | 2.012 |                |                            |                 |
| Tangible fixed asset                | 0.121               | 0.027                | <0.001 | 2.087 |                |                            |                 |
| Size classification = SME           | -26,410.780         | -0.021               | <0.001 | 1.437 |                |                            |                 |
| Size classification = Large company | -21,191.255         | -0.022               | <0.001 | 1.485 |                |                            |                 |

Source: own processing

From the perspective of impact quantification, the results show that an average increase in intangible assets by one thousand euros leads to an increase in operating revenue of 1,347 euros. This is a slightly higher effect compared to the value observed in the Slovak sample. For tangible fixed assets, the estimated impact is lower, with an increase of one thousand euros associated with an operating revenue increase of 121 euros. This suggests a relatively weaker direct effect of physical infrastructure on company performance. The strongest impact is again observed for the cost of goods sold variable, whose standardised coefficient of 0.957 highlights its dominant role in the revenue structure of companies. The negative coefficients of the dummy variables representing SMEs and large companies indicate that these categories reach lower average operating revenue levels than the reference group of the very large companies, which is consistent with the results obtained for Slovakia. The variance inflation factor values for all predictors remain below the commonly accepted threshold of 3, indicating no presence of multicollinearity and supporting the reliability and stability of the model.

## 4. Discussion

The results of this study confirm that intangible assets play an increasingly significant role in shaping company performance. The consistently higher growth of intangible assets compared to total assets across most size categories signals a structural shift in corporate asset composition toward knowledge-based resources. This observation corresponds with the conclusions of Dzenopoljac et al. (2024), who demonstrated a strong link between investment in intangibles and main financial indicators such as return on equity and EBITDA margin. In particular, the Slovak context stands out, as even SMEs displayed a statistically significant difference, underscoring a growing strategic orientation toward non-physical capital.

However, the relatively low effect sizes from the paired samples t-tests and only moderate correlation coefficients suggest that intangible assets, while influential, do not act in isolation. This finding resonates with the work of Hintzmann et al. (2021), who argue that firms in Central and Eastern Europe remain reliant on tangible inputs and may be in an earlier phase of transitioning toward models centred on intangible capital. The regression results in this study reflect this transitional stage. Although intangible assets exert a positive influence on revenue, variables such as cost of goods sold appear to play a more dominant role in explaining variations in performance outcomes.

Moreover, the lack of statistical significance in the Czech SMEs category, despite high average growth in intangible assets, points to important contextual factors. Dragomir (2024) emphasises that investment in intangible resources does not automatically lead to increased profitability, particularly in companies facing challenges related to managerial capacity or digital maturity. These findings highlight the importance of complementary organisational capabilities in fully leveraging intangible capital.

Company size also emerges as a key determinant in realising the benefits of intangible investments. Kapelko and Lansink (2013) found that larger companies tend to manage and exploit intangible resources more effectively, which aligns with this study's results showing more consistent impacts among very large companies. Nonetheless, as noted by Gostkowska-Drzewicka and Koralun-Bereznicka (2025), access to finance may limit the ability of some companies to invest in such assets, especially when external funding conditions are constrained.

Finally, Durst and Guldenberg (2009) draw attention to the long-term strategic function of intangible assets, which extend beyond immediate financial results. This perspective is echoed in the findings of the present study, particularly in the positive link between intangible asset accumulation and potential for growth. However, as Curea et al. (2022) caution, such potential is only realised when these investments are embedded within broader organisational strategies that support innovation, learning and transformation.

## 5. Conclusions

The study explored the role of intangible assets in shaping financial performance within manufacturing companies in Slovakia and the Czech Republic. The empirical analysis confirmed that intangible assets are growing at a faster pace than total assets, particularly in Slovak SMEs and very large companies. While the share of intangible assets in the overall capital structure remains relatively modest, the regression models demonstrate their positive contribution to revenue generation, often exceeding that of tangible fixed assets. Nonetheless, the explanatory power of intangible assets is not dominant, suggesting that their financial impact is conditional upon broader structural and organisational factors.

Notwithstanding the strong methodological framework, the study encounters multiple limitations. First, the exclusive focus on manufacturing companies may limit the

generalisability of results to other sectors with differing intangible asset profiles, such as services or information industries. Second, the analysis is constrained to company-level financial data, which do not fully capture qualitative dimensions such as innovation culture, strategic alignment or knowledge management practices.

Given these limitations, future research should consider incorporating additional variables that reflect organisational capabilities and strategic intent, possibly through mixed-method approaches that combine quantitative analysis with survey or interview data. Sectoral diversification and international benchmarking could also enhance the contextual understanding of intangible asset dynamics. Finally, further inquiry into the long-term effects of intangible accumulation could offer valuable insight into their strategic importance in sustaining competitive advantage, particularly in the face of digital and technological disruption.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Acknowledgments:** This research was financially supported by the Slovak Research and Development Agency Grant VEGA 1/0494/24: Metamorphoses and causalities of indebtedness, liquidity and solvency of companies in the context of the global environment.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

- Antzoulatos, A. A., Karanastasis, D., & Syrmos, T. (2022). The puzzling convergence of intangible investments. *International Advances in Economic Research*, 28(3–4), 171–182. <https://doi.org/10.1007/s11294-022-09862-7>
- Belloc, F., & Valentini, E. (2024). Dissecting environmental efficiency: The role of technology adoption and usage. *Journal of Economic Behavior & Organization*, 228, 106776. <https://doi.org/10.1016/j.jebo.2024.106776>
- Brynjolfsson, E., & McAfee, A. (2016). *The second machine age: Work Progress and Prosperity in a Time of Brilliant Technologies*. National Geographic Books.
- Corrado, C., Haskel, J., & Jona-Lasinio, C. (2017). Knowledge spillovers, ICT and productivity growth. *Oxford Bulletin of Economics and Statistics*, 79(4), 592–618. <https://doi.org/10.1111/obes.12171>
- Corrado, C., Haskel, J., & Jona-Lasinio, C. (2021). Artificial intelligence and productivity: an intangible assets approach. *Oxford Review of Economic Policy*, 37(3), 435–458. <https://doi.org/10.1093/oxrep/grab018>
- Curea, M., Mironiuc, M., & Huian, M. C. (2022). Intangibles, firm performance, and CEO characteristics: Spotlight on the EU electricity and gas industry. *Sustainability*, 14(15), 9195. <https://doi.org/10.3390/su14159195>
- Dragomir, V. D. (2024). The impact of intangible capital on firm profitability in the technology and healthcare sectors. *International Journal of Financial Studies*, 12(1), 5. <https://doi.org/10.3390/ijfs12010005>
- Durcova, J., & Pekarcik, M. (2023). Role of intangible assets in global value chains: Evidence from the Slovak Republic. *Strategic Management*, 28(4), 31–40. <https://doi.org/10.5937/straman2300036d>
- Durst, S., & Guldenberg, S. (2009). The meaning of intangible assets: New insights into external company succession in SMEs. *Electronic Journal of Knowledge Management*, 7(4), 437–446.
- Dzenopoljac, V., Rastic, A., & Dzenopoljac, A. (2024). The effect of intangible assets on Serbian firms' corporate financial performance. *Ekonomski Horizonti*, 26(2), 165–182. <https://doi.org/10.5937/ekonhor2402165d>
- Gostkowska-Drzewicka, M., & Koralun-Bereznicka, J. (2025). Capital structure specificity in knowledge-intensive industries: A comparative study of EU countries. *Journal of Entrepreneurship Management and Innovation*, 21(1), 99–120. <https://doi.org/10.7341/20252116>

- Gumbau-Albert, M. (2023). Understanding the impact of intangible capital on entrepreneurship at the regional level. *Journal of the Knowledge Economy*, 15(3), 11063-11089. <https://doi.org/10.1007/s13132-023-01511-6>
- Haskel, J., & Westlake, S. (2018). *Capitalism without capital: The Rise of the Intangible Economy*.
- Hintzmann, C., Lladós-Masllorens, J., & Ramos, R. (2021). Intangible assets and labor productivity growth. *Economies*, 9(2), 82. <https://doi.org/10.3390/economies9020082>
- Chen, W. (2018). Cross-Country Income Differences Revisited: Accounting for the role of intangible capital. *Review of Income and Wealth*, 64(3), 626-648. <https://doi.org/10.1111/roiw.12305>
- Kafourous, M., & Aliyev, M. (2015). Institutions and Foreign subsidiary Growth in transition Economies: The role of intangible Assets and Capabilities. *Journal of Management Studies*, 53(4), 580-607. <https://doi.org/10.1111/joms.12169>
- Kapelko, M., & Lansink, A. O. (2013). Examining the relation between intangible assets and technical efficiency in the international textile and clothing industry. *Journal of the Textile Institute*, 105(5), 491-501. <https://doi.org/10.1080/00405000.2013.826417>
- Juracka, D., Nagy, M., Valaskova, K., & Nica, E. (2024). A Meta-Analysis of Innovation Management in Scientific Research: Unveiling the frontier. *Systems*, 12(4), 130. <https://doi.org/10.3390/systems12040130>
- Labunska, S., Pylypenko, A., Sobakar, M., Filipova, L., & Hajnisova, E. (2024). Enterprises' innovative activity management oriented to their market value increase. *Entrepreneurship and Sustainability Issues*, 11(3), 238-245. [http://doi.org/10.9770/jesi.2024.11.3\(16\)](http://doi.org/10.9770/jesi.2024.11.3(16))
- McKinsey Global Institute. (2021). *The rise and rise of the global balance sheet: How productively are we using our wealth?* <https://www.mckinsey.com/industries/financial-services/our-insights/the-rise-and-rise-of-the-global-balance-sheet-how-productively-are-we-using-our-wealth>
- Nagy, M., Lazaroiu, G., & Valaskova, K. (2023). Machine intelligence and autonomous robotic technologies in the corporate context of SMES: deep learning and virtual simulation algorithms, Cyber-Physical production networks, and industry 4.0-Based manufacturing systems. *Applied Sciences*, 13(3), 1681. <https://doi.org/10.3390/app13031681>
- Roth, F., Sen, A., & Rammer, C. (2022). The role of intangibles in firm-level productivity – evidence from Germany. *Industry and Innovation*, 30(2), 263–285. <https://doi.org/10.1080/13662716.2022.2138280>
- Stan, S., Titu, M. A., & Paraschiv, C. (2024). The Role of Intangible Resources in Driving Value Creation and Sustained Competitive Advantage for Businesses. *Management of Sustainable Development*, 16(1), 106-115. <https://doi.org/10.54989/msd-2024-0010>
- Svarc, J., Laznjak, J., & Dabic, M. (2020). The role of national intellectual capital in the digital transformation of EU countries. Another digital divide? *Journal of Intellectual Capital*, 22(4), 768-791. <https://doi.org/10.1108/jic-02-2020-0024>
- Thum-Thysen, A., Voigt, P., Bilbao-Osorio, B., Maier, C., & Ognyanova, D. (2017). *Unlocking investment in intangible assets* (Discussion Paper 047). European Commission, Directorate-General for Economic and Financial Affairs.
- Ulnicane, I. (2020). Ever-changing Big Science and Research Infrastructures: Evolving European Union policy. In *Edward Elgar Publishing eBooks*. <https://doi.org/10.4337/9781839100017.00010>
- Van Assche, A. (2020). Trade, investment and intangibles. In *OECD Trade Policy Working Papers*. <https://doi.org/10.1787/750f13e6-en>
- Van Criekingen, K., Bloch, C., & Eklund, C. (2021). Measuring intangible assets—A review of the state of the art. *Journal of Economic Surveys*, 36(5), 1539-1558. <https://doi.org/10.1111/joes.12475>

## **EVALUATION OF THE USE OF ARTIFICIAL INTELLIGENCE IN MEDIUM AND LARGE ENTERPRISES IN THE CZECH BUSINESS ENVIRONMENT: AN HR MANAGER PERSPECTIVE**

Renata Skypalova<sup>1,a,\*</sup>, Zora Petrakova<sup>2,b</sup> and Zdenek Malek<sup>1,c</sup>

<sup>1</sup>Ambis University, Sujanovo namesti 356/1, 602 00 Brno, Czech Republic

<sup>2</sup>Slovak University of Technology in Bratislava, Institute for Forensic Engineering, Vazovova 5, 812 43 Bratislava, Slovakia

<sup>a</sup>renata.skypalova@ambis.cz, <sup>b</sup>zora.petrakova@stu.sk, <sup>c</sup>zdenek.malek@ambis.cz

\*Corresponding author

**Cite as:** Skypalova, R., Petrakova, Z., Malek, Z. (2025). *Evaluation of the Use of Artificial Intelligence in Medium and Large Enterprises in the Czech Business Environment: An HR Manager Perspective*, *Ekonomicko-manazerske spektrum*, 19(1), 28-38.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.28-38](https://doi.org/10.26552/ems.2025.1.28-38)

---

*Received: 14 December 2024; Received in revised form: 17 March 2025; Accepted: 30 March 2025; Available online: 30 June 2025*

### **Abstract:**

**Research background:** The use of artificial intelligence represents a modern approach to improving the strategic management of enterprises. Several studies have confirmed that gender plays a key role in the context of sustainable growth within the business environment.

**Purpose of the article:** The aim of this article was to evaluate the extent to which artificial intelligence is utilized in medium and large companies operating in the business environment of the Czech Republic.

**Methods:** A questionnaire was used to survey HR managers regarding the use of artificial intelligence in medium and large enterprises. A total of 451 HR managers from the business sector participated in the study. The research was conducted in 2024 in the Czech Republic. The assumption of normal distribution was tested using the Kolmogorov–Smirnov test, and homoscedasticity was evaluated using Levene’s test. Statistical hypotheses were verified using auxiliary statistics and the non-parametric Mann–Whitney U test.

**Findings & Value added:** The empirical results revealed several interesting findings. Statistically significant gender-based differences were observed in HR managers’ evaluations of artificial intelligence use. Male HR managers assessed AI applications more positively than their female counterparts, particularly in areas such as automation of administrative tasks, recruitment and selection, process efficiency, support for CSR report preparation, and management. However, no significant gender differences were found in the evaluation of AI’s impact on improving the employee experience.

**Keywords:** artificial intelligence; gender; HR manager; Czech business environment; perception

**JEL Classification:** M12; M14; O33

## **1. Introduction**

With the growth of digitization and digital transformation of enterprises in the context of business sustainability and the growth of the quality of the business environment, society, government organizations and enterprises themselves are increasingly aware that the use of artificial intelligence at a certain level is an indispensable need (Belas et al., 2025).

Several authors point to the positive aspects of the use of artificial intelligence (e.g. Mo et al., 2025). Especially in the context of: human resource management (e.g., employee stability and satisfaction; Belas et al., 2024); socially responsible entrepreneurship (e.g., when preparing ESG reports; Zvarikova et al., 2024; Zvarikova et al., 2023); business risk management in the enterprise (e.g., retaining its customers; Dvorsky et al., 2023); marketing activities of the enterprise (e.g., when searching for new markets; Valaskova et al., 2024), but also in the strategic management of the enterprise by the manager or owner of the enterprise (Dvorsky et al., 2024).

In the context of large enterprises, several authors have confirmed that there are differences in human resource management between men and women. These differences are reflected not only in human resource management (Aguinis et al., 2024; Elsayy and Elbadawe, 2022), but also in other aspects of business (e.g., the level of business digitization, business sustainability, financial performance; Balcerzak and Valaskova, 2024).

The uniqueness of the quantitative research is that the results of this research comprehensively evaluate the use of artificial intelligence in medium and large enterprises from the perspective of HR managers and their gender. In this context, a unique questionnaire was created.

The structure of the scientific article is as follows. In the first part, the authors formulate the motivations for addressing the issue of artificial intelligence (AI) and its possible impacts on business activity and the business environment at the national level. Subsequently, the research objective, methodological procedure, information about the questionnaire and statements were formulated, hypotheses and methods for their verification were defined, along with the presentation of the demographic structure of HR managers. Empirical results are presented through clear tables. In addition to a summary of key findings, the discussion also includes a comparison of findings in an international context. The conclusion defines the limits of the study and the further direction of the authors' research activities.

## **2. Methodology**

The aim of this paper is to evaluate the extent to which artificial intelligence is utilized in medium and large companies operating in the business environment of the Czech Republic.

### **2.1. Data collection**

To analyse and evaluate the level of implementation and use of AI in the business environment of the Czech Republic, a questionnaire was created, which is the most common form of asking questions and obtaining subjective opinions. The respondent was defined as a senior human resources officer (HR manager) of a business entity that carries out business activities in the business environment of the Czech Republic (hereinafter referred to as the "respondent").

The final version of the questionnaire was prepared taking into account the professional and technical comments and recommendations received from HR managers. The subsequent main collection of research data was carried out by an external agency that is well established not

only in the business environment of the Czech Republic, but throughout Central Europe. The external research agency is one of the few companies operating and able to collect data in several EU countries. Respondents were selected from the agency's internal database using the Computer-Assisted Web Interview (CAWI) methodology. MNFORCE ensured the protection of the questionnaire from misuse by third parties. The research agency regularly verifies and updates information about the companies in its portfolio. The research agency also ensured the representativeness of the sample of respondents in terms of relevant demographic characteristics that were included in the questionnaire. The demographic structure of the research sample in individual groups of respondents was set to reflect the structure of the basic set of respondents in a given group in the Czech Republic. In this step, the agency used data from the Czech Statistical Office as of 31.12.2023.

The basic criterion for including a respondent in the research set was that the respondent had to be an HR manager of a medium or large enterprise that carries out business activities in the business environment of the Czech Republic. Compliance with this selection criterion was guaranteed by the aforementioned research agency MNFORCE.

Another criterion for data collection was the size of the sample set. Given the results of the minimum number of respondents, which were carried out in the Gretl program, the research sample of 451 HR managers is sufficiently large. This is because it exceeds by more than 10% the minimum sample size required for statistical research through a questionnaire survey.

MNFORCE also ensured the protection of the questionnaire from automated filling and hacker attacks. At the same time, it committed to adhering to ethical principles and research integrity in the actual implementation of data collection and creation of the research file.

The total number of respondents was 451 HR managers. At the beginning of the questionnaire, a question was formulated as to whether the respondent agreed that his or her attitudes and opinions could be used for scientific research purposes. Four respondents answered negatively and were subsequently excluded from the research data set. The final sample consisted of 447 HR managers who gave their consent to their answers being used for scientific research purposes.

## **2.2. Questionnaire and statements**

The final version of the questionnaire consisted of several separate parts. The first part of the questionnaire formulated basic information about the research intention, research gap and planned scientific research outputs that will be created from the given quantitative research set. Respondents were asked to fill out the questionnaire truthfully and relevantly, with the proviso that in the event of impossibility or incompetence to answer all the questions truthfully, they had the option to stop filling out the questionnaire immediately at the given question. In such a case, of course, the given respondent was not included in the research sample of respondents. The introduction also included a question about the respondent's explicit consent to the publication of his answers for scientific purposes.

Respondents were required to express their position on individual statements regarding the use of artificial intelligence in the company using a 4-point Likert scale: (i) I completely disagree (numerical value 1); (ii) I tend to disagree (2); (iii) I tend to agree (3); and (iv) I completely agree (4).

Table 1 presents the formulation of statements to the using of artificial intelligence.

## **2.3. Statistical hypotheses and methods**

To achieve the main objective of the article, the following statistical hypotheses were formulated (SH1-SH6).

*Table 1: Formulation of statements to the using of artificial intelligence in the company (AI)*

| Items      | Definition of the statements                                                                                                                                                                      |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>AI1</b> | The company uses AI to automate repetitive and time-consuming tasks (e.g. payroll processing, employee data management, shift planning, etc.).                                                    |
| <b>AI2</b> | The company uses AI in employee selection (e.g. CV screening, candidate evaluation, predicting candidate success based on historical data).                                                       |
| <b>AI3</b> | The company uses AI to obtain feedback, information on satisfaction, as well as recommendations and advice from its employees.                                                                    |
| <b>AI4</b> | Our company uses AI to increase the efficiency of internal processes.                                                                                                                             |
| <b>AI5</b> | The organization uses AI to support the preparation of materials for the CSR report (for the annual report, for a separate CSR report, for a sustainability report) or other strategic documents. |
| <b>AI6</b> | The organization's management is committed to supporting the use of AI in the daily work activities of employees.                                                                                 |

*Source: data collected by the authors*

SH: The gender of the HR manager does not have a statistically significant impact on the assessment of statements AI1 (SH1), AI2 (SH2), AI3 (SH3), AI4 (SH4), AI5 (SH5), AI6 (SH6) in medium and large enterprises in the business environment of the Czech Republic. There are no statistically significant differences in the assessment of statements AI1-AI6 between respondents with respect to the gender of the HR manager.

The aim of descriptive statistics is to present the basic results of the evaluation of the defined statements of the questionnaire survey. This is done using the absolute and relative frequencies (percentages) of the perception of selected statements by HR managers in clear contingency tables (see e.g. Table 2 and Table 3 – descriptive characteristics). These were created using the method of simple sorting of a statistical feature. The above tables contain the evaluation of statements on AI according to the gender of the HR manager. These were created using the method of sorting according to two statistical features (gender, defined statement on AI).

With regard to the investigation and verification of the influence of the gender of the HR manager on the perception of statements on AI, the subject of the analysis will be the verification of the assumptions for performing parametric testing using ANOVA: (i) normal distribution using the Kolmogorov-Smirnov test ( $n > 50$ , see Table 3); and (ii) verification of homoskedasticity using the Levene test (see Table 4). In case the assumptions for applying parametric tests are not met, non-parametric tests will be used; Mann-Whitney U test (see Table 5 and Table 6). The assumption of normal distribution is considered accepted if the p-value (Sig.) of the Kolmogorov-Smirnov statistic is greater than the significance level ( $\alpha = 0.05$ ). The assumption of homoscedasticity of variances of statement evaluations in selected groups by gender is met if the p-value (Sig.) of the Levene statistic is greater than the significance level ( $\alpha = 0.05$ ).

## **2.4. Structure of HR managers**

Structure of enterprises by number of employees (size of enterprise): i. 278 (62.2%) medium-sized enterprises with 51 to 249 employees, ii. 169 (37.8%) large enterprises with 250 or more employees. Structure of enterprises according to whether they are family businesses: (i) 144 (32.2%) yes; (ii) 261 (58.4%) no; and (iii) 42 (9.4%) don't know. Structure of enterprises according to whether the enterprise is international (doing business in a foreign business environment): (i) 264 (59.1%) purely Czech company (without foreign investor); (ii) 109 (24.4%) company with Czech and foreign investors; (iii) 48 (10.7%) only foreign investor (branch of a multinational company) and (iv) 26 (5.8%) don't know.

Structure of companies by location of company headquarters in the Czech Republic: (i) 128 (28.6%) Capital Prague; (ii) 23 (5.1%) South Moravian Region; (iii) 54 (12.1%) South Moravian Region; (iv) 9 (2.0%) Karlovy Vary Region; (v) 20 (4.5%) Hradec Kralove Region;

(vi) 15 (3.4%) Liberec Region; (vii) 54 (12.1%) Moravian-Silesian Region; (vii) 26 (5.8%) Olomouc Region; (ix) 20 (4.5%) Pardubice Region; (x) 18 (4.0%) Plzen Region; (xi) 20 (4.5%) Central Bohemian Region; (xii) 17 (3.8%) Usti nad Labem Region; (xiii) 24 (5.4%) Vysocina Region; and (xiv) 19 (4.3%) Zlin Region.

Structure of respondents by gender: (i) 183 (40.9%) men; and (ii) 264 (59.1%) women. Structure of respondents by age of HR manager: (i) 31 (3.9%) generation Z; (ii) 189 (42.3%) generation Y; (iii) 194 (43.4%) generation X; and (iv) 33 (7.4%) baby boom. Structure of respondents by highest education of HR manager: (i) 249 (55.7%) complete secondary education with school leaving certificate; while (ii) 198 (44.3%) university education (Bc., Ing./Mgr., PhD., doc., prof.)

### 3. Results

#### 3.1. Descriptive statistics and contingency tables

The following contingency tables (see table 2) presents the results of the analysis of respondents' attitudes towards selected statements about the use of artificial intelligence in the company.

*Table 2: Contingency tables of evaluation of AI statements*

| TA | AI1       |      |           |      |           |      | AI2       |      |           |      |           |      |
|----|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|
|    | SUME      |      | M         |      | F         |      | SUME      |      | M         |      | F         |      |
|    | (n = 447) |      | (n = 183) |      | (n = 264) |      | (n = 447) |      | (n = 183) |      | (n = 264) |      |
|    | n         | %    | n         | %    | n         | %    | n         | %    | n         | %    | n         | %    |
| 1  | 104       | 23.3 | 32        | 17.5 | 72        | 27.3 | 144       | 32.2 | 49        | 26.8 | 95        | 36.0 |
| 2  | 125       | 28.0 | 52        | 28.4 | 73        | 27.7 | 129       | 28.9 | 52        | 28.4 | 77        | 29.1 |
| 3  | 150       | 33.6 | 66        | 36.1 | 84        | 31.7 | 129       | 28.9 | 62        | 33.9 | 67        | 25.4 |
| 4  | 68        | 15.1 | 33        | 18.0 | 35        | 13.3 | 45        | 10.0 | 20        | 10.9 | 25        | 9.5  |
| TA | AI3       |      |           |      |           |      | AI4       |      |           |      |           |      |
|    | SUME      |      | M         |      | F         |      | SUME      |      | M         |      | F         |      |
|    | (n = 447) |      | (n = 183) |      | (n = 264) |      | (n = 447) |      | (n = 183) |      | (n = 264) |      |
|    | n         | %    | n         | %    | n         | %    | n         | %    | n         | %    | n         | %    |
| 1  | 120       | 26.8 | 44        | 24.0 | 76        | 28.8 | 113       | 25.3 | 40        | 21.9 | 73        | 27.7 |
| 2  | 137       | 30.7 | 52        | 28.4 | 85        | 32.2 | 132       | 29.5 | 48        | 26.2 | 84        | 31.8 |
| 3  | 138       | 30.9 | 64        | 35.0 | 74        | 28.0 | 146       | 32.7 | 66        | 36.1 | 80        | 30.3 |
| 4  | 52        | 11.6 | 23        | 12.6 | 29        | 11.0 | 56        | 12.5 | 29        | 15.8 | 27        | 10.2 |
| TA | AI5       |      |           |      |           |      | AI6       |      |           |      |           |      |
|    | SUME      |      | M         |      | F         |      | SUME      |      | M         |      | F         |      |
|    | (n = 447) |      | (n = 183) |      | (n = 264) |      | (n = 447) |      | (n = 183) |      | (n = 264) |      |
|    | n         | %    | n         | %    | n         | %    | n         | %    | N         | %    | n         | %    |
| 1  | 115       | 25.7 | 42        | 23.0 | 73        | 27.7 | 115       | 25.7 | 37        | 20.2 | 78        | 29.5 |
| 2  | 143       | 32.0 | 54        | 29.5 | 89        | 33.7 | 131       | 29.3 | 54        | 29.5 | 77        | 29.2 |
| 3  | 139       | 31.1 | 57        | 31.1 | 82        | 31.1 | 145       | 32.4 | 56        | 30.6 | 89        | 33.7 |
| 4  | 50        | 11.2 | 30        | 16.4 | 20        | 7.6  | 56        | 12.6 | 36        | 19.7 | 20        | 7.6  |

*Note: TA – Type of answer; AI1-AI6 - Artificial intelligence statements; M – Male; F – Female; n – number of respondents*

*Source: data collected by the authors*

The results reveal the following findings (see Table 2):

- Only every second company (specifically 51.3%) agreed, either somewhat or completely, with the statement that it uses AI to automate repetitive and time-consuming tasks (AI1). From the gender perspective, it is evident that female HR managers (55.0%) report a higher use of AI in this context compared to male HR managers (45.9%).

- More than 6 out of 10 surveyed HR managers (specifically 61.1%) stated that their company uses AI in employee selection (AI2). From a gender perspective, female HR managers (65.1%) agreed with this statement to a greater extent than their male counterparts (55.2%).
- Fewer than 6 out of 10 HR managers (specifically 57.5%) reported that their company uses AI to gather feedback on employee satisfaction, suggestions, and advice (AI3). Again, female HR managers (61.0%) showed a higher level of agreement compared to male HR managers (52.4%).
- Only 54.8% of the surveyed HR managers indicated that their company uses AI to improve internal process efficiency (AI4). Comparing responses by gender shows that female HR managers (59.5%) agreed more strongly with this statement than male HR managers (48.1%).
- Exactly 57.7% of the HR managers stated that their company uses AI in the preparation of CSR reports or other strategic documents (AI5). From a gender perspective, female HR managers (61.4%) agreed more frequently than male HR managers (52.5%).
- Exactly 55.0% of the HR managers indicated that their company promotes the use of AI in employees' daily work activities (AI6). A gender-based comparison reveals that female HR managers (58.7%) agreed with this statement more often than male HR managers (49.7%).

Table 3 summarizes the results of selected descriptive statistics indicators related to the statements on the use of artificial intelligence in the company (AI: AI1-AI6).

*Table 3: Descriptive statistics of AI statements according to the gender (M/F)*

| DS  | Artificial intelligence (AI) |             |             |             |             |             |
|-----|------------------------------|-------------|-------------|-------------|-------------|-------------|
|     | AI1                          | AI2         | AI3         | AI4         | AI5         | AI6         |
| ME  | 2.546/2.311                  | 2.290/2.083 | 2.361/2.212 | 2.459/2.231 | 2.410/2.186 | 2.497/2.193 |
| SE  | 0.073/0.062                  | 0.073/0.061 | 0.073/0.060 | 0.074/0.060 | 0.075/0.057 | 0.076/0.058 |
| SD  | 0.982/1.014                  | 0.982/0.995 | 0.984/0.983 | 1.004/0.969 | 1.017/0.927 | 1.026/0.950 |
| SK  | 0.984/1.133                  | 1.082/0.985 | 1.060/0.997 | 1.079/1.003 | 1.107/0.941 | 1.124/1.077 |
| KU  | 0.114/0.118                  | 0.093/0.416 | 0.028/0.265 | 0.068/0.205 | 0.058/0.200 | 0.008/0.142 |
| MIN | 1.000/1.000                  | 1.000/1.000 | 1.000/1.000 | 1.000/1.000 | 1.000/1.000 | 1.000/1.000 |
| MAX | 4.000/4.000                  | 4.000/4.000 | 4.000/4.000 | 4.000/4.000 | 4.000/4.000 | 4.000/4.000 |

*Note: DS – Descriptive statistics; AI1-AI6 – Artificial intelligence statements; M – Male; F – Female; ME – Mean; SE – Standard error; SD – Standard deviation; SK – Skewness; KU – Kurtosis; MIN – Minimum; MAX – Maximum*  
*Source: data collected by the authors*

The results indicate that the greatest differences in evaluation between male and female respondents were observed for statement AI6 (Male HR managers: ME = 2.497; Female HR managers: ME = 2.193). On the contrary, the highest level of agreement between respondents by gender was found in the evaluation of statement AI3 (Male HR managers: ME = 2.361; Female HR managers: ME = 2.212).

### 3.2. Verification of assumptions (normality and homoscedasticity)

The following tables (see Table 4 and Table 5) present the results of verifying the assumptions (normal distribution and homoskedasticity) for conducting parametric testing to identify differences in HR managers' perceptions of statements formulated regarding the use of artificial intelligence in the company.

The results (see Table 4) show that the assumption of normal distribution for the selected variables (AI1-AI6) is not met, both for both groups of respondents by gender because the p-values of the Kolmogorov-Smirnov statistic are lower than the significance level ( $\alpha = 0.05$ ).

*Table 4: Verification of the assumption - normal distribution according to the gender (M/F)*

| Gender |   | Kolmogorov-Smirnov |     | Shapiro-Wilk |           |     |       |
|--------|---|--------------------|-----|--------------|-----------|-----|-------|
|        |   | Statistic          | df  | Sig.         | Statistic | df  | Sig.  |
| AI1    | M | 0.219              | 183 | 0.000        | 0.877     | 183 | 0.000 |
|        | F | 0.202              | 264 | 0.000        | 0.867     | 264 | 0.000 |
| AI2    | M | 0.213              | 183 | 0.000        | 0.866     | 183 | 0.000 |
|        | F | 0.222              | 264 | 0.000        | 0.845     | 264 | 0.000 |
| AI3    | M | 0.217              | 183 | 0.000        | 0.871     | 183 | 0.000 |
|        | F | 0.195              | 264 | 0.000        | 0.865     | 264 | 0.000 |
| AI4    | M | 0.224              | 183 | 0.000        | 0.872     | 183 | 0.000 |
|        | F | 0.192              | 264 | 0.000        | 0.867     | 264 | 0.000 |
| AI5    | M | 0.195              | 183 | 0.000        | 0.874     | 183 | 0.000 |
|        | F | 0.197              | 264 | 0.000        | 0.864     | 264 | 0.000 |
| AI6    | M | 0.191              | 183 | 0.000        | 0.875     | 183 | 0.000 |
|        | F | 0.215              | 264 | 0.000        | 0.857     | 264 | 0.000 |

*Note: AI1-AI6 – Artificial intelligence statements; M – Male; F – Female*

*Source: data collected by the authors*

This means that the selected variables (AI1-AI6) do not have the shape of a probability model of normal distribution. The results (see Table 5) also show that the assumption of homoskedasticity of variances is met for each monitored variable (AI1-AI6). This is because the p-values of the Levene statistic are greater than the significance level ( $\alpha = 0.05$ ).

*Table 5: Verification of the assumption - homoscedasticity*

|     |                                      | Levene<br>Statistic | df1 | df2     | Sig.  |
|-----|--------------------------------------|---------------------|-----|---------|-------|
| AI1 | Based on Mean                        | 0.566               | 1   | 445     | 0.452 |
|     | Based on Median                      | 0.434               | 1   | 445     | 0.510 |
|     | Based on Median and with adjusted df | 0.434               | 1   | 437.792 | 0.510 |
|     | Based on trimmed mean                | 0.508               | 1   | 445     | 0.476 |
| AI2 | Based on Mean                        | 0.288               | 1   | 445     | 0.591 |
|     | Based on Median                      | 0.149               | 1   | 445     | 0.700 |
|     | Based on Median and with adjusted df | 0.149               | 1   | 444.783 | 0.700 |
|     | Based on trimmed mean                | 0.556               | 1   | 445     | 0.456 |
| AI3 | Based on Mean                        | 0.265               | 1   | 445     | 0.607 |
|     | Based on Median                      | 0.802               | 1   | 445     | 0.371 |
|     | Based on Median and with adjusted df | 0.802               | 1   | 444.998 | 0.371 |
|     | Based on trimmed mean                | 0.403               | 1   | 445     | 0.526 |
| AI4 | Based on Mean                        | 1.146               | 1   | 445     | 0.285 |
|     | Based on Median                      | 1.304               | 1   | 445     | 0.254 |
|     | Based on Median and with adjusted df | 1.304               | 1   | 427.322 | 0.254 |
|     | Based on trimmed mean                | 1.391               | 1   | 445     | 0.239 |
| AI5 | Based on Mean                        | 5.185               | 1   | 445     | 0.023 |
|     | Based on Median                      | 4.746               | 1   | 445     | 0.030 |
|     | Based on Median and with adjusted df | 4.746               | 1   | 438.126 | 0.030 |
|     | Based on trimmed mean                | 5.725               | 1   | 445     | 0.017 |
| AI6 | Based on Mean                        | 3.033               | 1   | 445     | 0.082 |
|     | Based on Median                      | 3.439               | 1   | 445     | 0.064 |
|     | Based on Median and with adjusted df | 3.439               | 1   | 424.139 | 0.064 |
|     | Based on trimmed mean                | 3.400               | 1   | 445     | 0.066 |

*Note: AI1-AI6 – Artificial intelligence statements*

*Source: data collected by the authors*

### 3.3. Non-parametric tests

Based on the results of testing the assumptions of normal distribution and homoscedasticity, it was concluded that parametric testing could not be applied to determine statistically significant differences in HR managers' evaluations of AI-related statements by gender. The

following tables (see Table 6 and Table 7) summarize the results of the comparison of HR managers' attitudes by gender using non-parametric testing.

*Table 6: Mann-Withney U test – rank evaluation of AI statements*

| Gender | N   | Mean of Rank | Sum of Ranks | Gender | N   | Mean of Rank | Sum of Ranks |
|--------|-----|--------------|--------------|--------|-----|--------------|--------------|
| AI1 M  | 183 | 241.0        | 44,107       | AI4 M  | 183 | 240.9        | 44,083       |
| F      | 264 | 212.2        | 56,022       | F      | 264 | 212.3        | 56,046       |
| Total  | 447 |              |              | Total  | 447 |              |              |
| AI2 M  | 183 | 239.8        | 43,877       | AI5 M  | 183 | 239.9        | 43,905       |
| F      | 264 | 213.1        | 56,252       | F      | 264 | 213.0        | 56,223       |
| Total  | 447 |              |              | Total  | 447 |              |              |
| AI3 M  | 183 | 235.4        | 43,081       | AI6 M  | 183 | 245.3        | 44,886       |
| F      | 264 | 216.1        | 57,048       | F      | 264 | 209.3        | 55,242       |
| Total  | 447 |              |              | Total  | 447 |              |              |

*Source: data collected by the authors*

The results (see Table 6 and Table 7) reveal the following empirical findings. The gender of the HR manager is a statistically significant factor influencing the evaluation of statements related to the use of artificial intelligence (AI1-AI6), with the exception of AI3. The results of the non-parametric tests confirmed that the p-values of the Mann–Whitney (M–W) statistics for AI-related statements (ranging from AI6: *Sig* = 0.003 to AI2: *Sig* = 0.025) are lower than the established significance level ( $\alpha$  = 0.05).

The gender of the HR manager is not a statistically significant factor influencing the evaluation of statement AI3. This is because the p-value (*Sig* = 0.105) of the M–W test is higher than the significance level ( $\alpha$  = 0.05). Thus, gender does not have a statistically significant impact on the evaluation of statement AI3.

*Table 7: Results of nonparametric tests*

| Non-parametric tests   | Artificial intelligence |           |           |           |           |           |
|------------------------|-------------------------|-----------|-----------|-----------|-----------|-----------|
|                        | AI1                     | AI2       | AI3       | AI4       | AI5       | AI6       |
| Mann-Whitney U         | 21041.500               | 21271.500 | 22067.500 | 21065.500 | 21243.000 | 20262.000 |
| Wilcoxon W             | 56021.500               | 56251.500 | 57047.500 | 56045.500 | 56223.000 | 55242.000 |
| Z                      | -2.412                  | -2.242    | -1.621    | -2.397    | -2.263    | -3.020    |
| Asymp. Sig. (2-tailed) | 0.016                   | 0.025     | 0.105     | 0.017     | 0.024     | 0.003     |

*Source: data collected by the authors*

Table 8 provides a summary overview of the evaluation of the formulated statistical hypotheses.

*Table 8: Evaluation of differences in the perceptions on the AI statements according to the gender*

| Items | Definition of the statements                                                                                                                                                                      | Statistical hypotheses | Evaluation | Gender Differences |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------|--------------------|
| AI1   | The company uses AI to automate repetitive and time-consuming tasks (e.g. payroll processing, employee data management, shift planning, etc.).                                                    | SH1                    | rejected   | yes                |
| AI2   | The company uses AI in employee selection (e.g. CV screening, candidate evaluation, predicting candidate success based on historical data).                                                       | SH2                    | rejected   | yes                |
| AI3   | The company uses AI to obtain feedback, information on satisfaction, as well as recommendations and advice from its employees.                                                                    | SH3                    | accepted   | no                 |
| AI4   | Our company uses AI to increase the efficiency of internal processes.                                                                                                                             | SH4                    | rejected   | yes                |
| AI5   | The organization uses AI to support the preparation of materials for the CSR report (for the annual report, for a separate CSR report, for a sustainability report) or other strategic documents. | SH5                    | rejected   | yes                |
| AI6   | The organization's management is committed to supporting the use of AI in the daily work activities of employees.                                                                                 | SH6                    | rejected   | yes                |

*Source: data collected by the authors*

## 4. Discussion

The evaluation of HR managers' attitudes toward statements regarding the use and implementation of AI in their companies shows that the level of agreement with statements AI1 to AI6 ranges from 51.3% to 61.1%. The highest level of agreement (somewhat agree + strongly agree) was observed for the use of AI in recruitment and employee selection (AI2: 61.1%), while the lowest level of agreement was related to the automation of administrative tasks (AI1: 51.3%).

A gender-based comparison reveals that female HR managers reported a higher level of agreement (ranging from AI1: 55.0% to AI2: 65.1%) with the statements on the use and implementation of AI in their companies (AI1 to AI6), compared to their male counterparts (ranging from AI1: 45.9% to AI2: 55.2%).

Empirical findings have confirmed that artificial intelligence (AI) is beginning to play a significant role in the management of human resources within business entities. This partial conclusion aligns directly with the findings of Kekez et al. (2025), Klietk et al. (2023), and Mura and Stehlikova (2025). In this context, Kosikova and Matovicikova (2024) and Bankins et al. (2022) argue that the use of AI significantly contributes to the expansion and transformation of the digital working environment for entrepreneurs.

Male HR managers are more likely to utilize AI for automating repetitive and time-consuming tasks compared to their female counterparts. Similar gender-based disparities were also identified in the use of AI during the recruitment process—particularly in the initial screening of résumés and the evaluation of candidates. These conclusions, rooted in differing perspectives between male and female HR managers, are consistent with the findings of Elbadawi (2024), Belas et al. (2025), and Elsayy and Elbadawe (2022).

Significant gender-based differences were also observed in the attitudes of HR managers towards the use of AI in enhancing the efficiency of internal procedures, as well as in the application of AI in preparing corporate social responsibility (CSR) reports and other strategic documents. Female HR managers were less inclined to utilize AI in the aforementioned HR functions. In this regard, gender emerges as a significant factor not only in the adoption of AI technologies but also in relation to employee-related risks (e.g., error rates, flexibility, etc.; Frajtova-Michalikova et al., 2024) and the broader organization of human capital within firms (Remeikiene et al., 2025; Khan et al., 2024).

In this context, the findings of Piwowar-Sulej and Cierniak-Emerych (2024) and Zvarikova et al. (2024) are also noteworthy, as their studies addressed employee satisfaction within the framework of socially responsible business practices and business sustainability.

## 5. Conclusions

The aim of this article was to evaluate the extent to which artificial intelligence is utilized in medium and large companies operating in the business environment of the Czech Republic.

Among the key findings regarding the attitudes of HR managers is the fact that 50% to 60% of Czech medium and large enterprises use AI within their operations. The attitudes of male and female HR managers toward statements about the use of artificial intelligence differ significantly, with the exception of statement AI3 (the company uses AI for feedback, gathering information on employee satisfaction, as well as suggestions and advice from employees). Male HR managers evaluated the use of AI in the company significantly more positively compared to their female counterparts.

Empirical findings serve as a crucial catalyst for medium and large enterprises in the adoption, implementation, and utilization of artificial intelligence within internal human

resource management processes. Recognizing the differences in human resource (HR) management styles based on the gender of HR managers has demonstrable positive effects on the overall management of the organization. These benefits are particularly evident in the efficiency of HR department employees, the quality of candidate selection processes for potential new hires, the reduction of financial costs related to HR management, and, not least, in the management approach of HR professionals who are aware of such differences.

However, the research has certain limitations that influence the obtained findings. Primarily, the study was conducted only at the local level, specifically within a single Central European country—the Czech Republic. The responses of HR managers to selected questionnaire items are inherently subjective and may vary over time. Furthermore, the choice and interpretative power of results derived from the testing of statistical hypotheses using non-parametric tests also possess inherent limitations.

Future research will be directed along several lines. One key objective is to expand the study to other European Union countries to enable broader generalization and applicability of the empirical findings. Another goal is to replicate the research after a time interval in order to compare the results longitudinally. Additionally, future studies will aim to verify the current findings using alternative mathematical and statistical methodologies (e.g., logistic regression, correspondence analysis, structural equation modelling), which will constitute the basis for further scientific and publication outputs.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** Data are available from the authors upon reasonable request.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Aguinis, H., Beltran, J.R., & Cope, A. (2024). How to use generative AI as a human resource management assistant. *Organizational Dynamics*, 53(1), 101029. <https://doi.org/10.1016/j.orgdyn.2024.101029>
- Balcerzak, A. P., & Valaskova, K. (2024). Artificial intelligence: Financial management under pressure of transformative technology. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 19(4), 1127-1137. <https://doi.org/10.24136/eq.3394>
- Bankins, S., Formosa, P., Griep, Y., & Richards, D. (2022). AI decision making with dignity? Contrasting workers' justice perceptions of human and ai decision making in a human resource management context. *Information Systems Frontiers*, 24(3), 857-875. <https://doi.org/10.1007/s10796-021-10223-8>
- Belas, J., Dvorsky, J., Hlawiczka, R., Smrcka, L., & Khan, K. A. (2024). SMEs sustainability: The role of human resource management, corporate social responsibility and financial management. *Oeconomia Copernicana*, 15(1), 307-342. <https://doi.org/10.24136/oc.2937>
- Belas, J., Klietnik, T., Dvorsky, J. & Streimikiene, D. (2025). Exploring Gender-Based Disparities in the Digital Transformation and Sustainable Development of SMEs in V4 Countries. *Journal of Innovation & Knowledge*, 10(2), 100681. <https://doi.org/10.1016/j.jik.2025.100681>
- Dvorsky, J., Frajtova-Michalikova, K., & Zvarikova, K. (2024). Effect of Selected Determinants on the Sustainability of SMEs: Does Gender Matter? *Administrative Sciences*, 14(11), 281. <https://doi.org/10.3390/admsci14110281>
- Dvorsky, J., Olah, J., Bednarz, J., Hudakova, M. (2023). Opinions of owners and top manager on the business risks of SMEs sustainability: Does gender matter? *Journal of Business, Economics and Management*, 24(4), 732-753. <https://doi.org/10.3846/jbem.2023.20232>
- Elbadawi, M. A. (2024). Exploring the Impact of AI on Employee Engagement and Productivity in Human Resource Management. *Studies in Big Data*, 158, 541-550. [https://doi.org/10.1007/978-3-031-70855-8\\_46](https://doi.org/10.1007/978-3-031-70855-8_46)

- Elsawy, M. M., & Elbadawe, M. A. (2022). The impact of gender-based human resource practices on employee performance: An empirical analysis. *International Journal of Business and Management*, 17(6), 1-12. <https://doi.org/10.5539/ijbm.v17n6p1>
- Frajtova-Michalikova, K., Imam, H., Pobee, F., & Rozhan, S. M. B. (2024). Comparative analysis of key personal traits of SME owners and managers. A perspective from business sectors. *Journal of Business Sectors*, 2 (2), 40–49. <https://doi.org/10.62222/PSRV2054>
- Kekez, I., Lauwaert, L., & Redep, N. B. (2025). Is artificial intelligence (AI) research biased and conceptually vague? A systematic review of research on bias and discrimination in the context of using AI in human resource management. *Technology in Society*, 81, 102818. <https://doi.org/10.1016/j.techsoc.2025.102818>
- Khan, H. M. N., Hossein, M. S., & Imam, H. (2024). Pre-employment background check: A review and research agenda. *Journal of Business Sectors*, 2(2), 31–39. <https://doi.org/10.62222/AXPC9543>
- Kliestik, T., Nica, E., Durana, P., & Popescu, G. H. (2023). Artificial intelligence-based predictive maintenance, time-sensitive networking, and big data-driven algorithmic decision-making in the economics of Industrial Internet of Things. *Oeconomia Copernicana*, 14(4), 1097-1138. <https://doi.org/10.24136/oc.2023.033>
- Kosikova, M., & Matovcikova, D. (2024). The Impact of Digital Quality of Life on Artificial Intelligence Development: A Case Study Using the DQL and AIRI Indexes, *Ekonomicko-manazerske spektrum*, 18(2), 24-37. <https://dx.doi.org/10.26552/ems.2024.2.24-37>
- Mo, Z., Liu, M.T., Chark, R., Zeng, S., & Song, X. (2025). How AI adoption in human resource management practices can enhance tourism employees' organizational commitment. *Journal of Hospitality and Tourism Management*, 63, 54-67. <https://dx.doi.org/10.1016/j.jhtm.2025.03.003>
- Mura, L., & Stehlikova, B. (2025). Artificial intelligence: Effective HR assistant or invisible dictator?. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 20(1), 15-33. <https://doi.org/10.24136/eq.3598>
- Piowar-Sulej, K., & Cierniak-Emerych, A. (2024). How to measure employees' interests so as to be a more socially-responsible employer: A proposal of a new scale and its validation. *Oeconomia Copernicana*, 15(1), 267-306. <https://doi.org/10.24136/oc.2571>
- Remeikiene, R., Gaspareniene, L., & Cesulyte, J. (2025). Work Organization and Social Responsibility on Digital Platforms: Challenges and Best Practices in Europe. *Journal of Business Sectors*, 3(1), 25–40. <https://doi.org/10.62222/TDGY8465>
- Valaskova, K., Nagy, M., & Grecu, G. (2024). Digital twin simulation modeling, artificial intelligence-based Internet of Manufacturing Things systems, and virtual machine and cognitive computing algorithms in the Industry 4.0-based Slovak labor market. *Oeconomia Copernicana*, 15(1), 95-143. <https://doi.org/10.24136/oc.2814>
- Zvarikova, K., Jurkowska-Gomulka, A., Dvorsky, J., & Belas, J. (2023). Business ethics in the SME sector – Do firm size and the gender and education level of entrepreneurs play a role? *Intellectual Economics*, 17(1), 57-72. <https://doi.org/10.13165/IE-23-17-1-03>
- Zvarikova, K., Musova, Z., Rowland, Z., & Skypalova, R. (2024). Factors determining the implementation of corporate social responsibility in the SME segment in the V4 region. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 19(4), 1327-1362. <https://doi.org/10.24136/eq.3365>

## PRICE DEVELOPMENT OF GOLD AND S&P 500 INDEX AS A DETERMINANT OF INVESTMENT BEHAVIOR: A COMPARATIVE ANALYSIS

Ana Madalina Potcovaru<sup>1,a,\*</sup>, Elvira Nica<sup>1,b</sup> and Ema Labudova<sup>2,c</sup>

<sup>1</sup>University of Economic Studies, Administration and Public Management Faculty, Department of Administration and Public Management, 6 Piata Romana, 1st district, 010374 Bucharest, Romania

<sup>2</sup>University of Zilina, Faculty of Operation and Economics of Transport and Communications, Department of Economics, Univerzitna 1, 010 26 Zilina, Slovakia

<sup>a</sup>ana.potcovaru@amp.ase.ro, <sup>b</sup>elvira.nica@man.ase.ro, <sup>c</sup>labudova9@stud.uniza.sk

\*Corresponding author

**Cite as:** Potcovaru, A.-M., Nica, E., Labudova, E. (2025). Price development of gold and S&P 500 index as a determinant of investment behavior: A comparative analysis, *Ekonomicko-manazerske spektrum*, 19(1), 39-54.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.39-54](https://dx.doi.org/10.26552/ems.2025.1.39-54)

---

Received: 21 December 2024; Received in revised form: 2 April 2025; Accepted: 5 April 2025; Available online: 30 June 2025

### Abstract:

**Research background:** While gold is traditionally viewed as a safe haven and a store of value, especially in times of economic uncertainty, the S&P 500 index reflects broader market sentiment and offers higher return potential over the long term—albeit with greater volatility.

**Purpose of the article:** The aim of this study is to provide a comparative analysis of the price development of gold and the S&P 500 index across different time periods and economic conditions, in order to offer recommendations for optimizing investment decisions and enhancing portfolio diversification.

**Methods:** The theoretical framework is based on investment decision-making from the perspective of risk, return, and individual investor preferences. The empirical part analyses historical data on the price development of gold and the S&P 500 index from February 2015 to February 2025, with the Pearson correlation coefficient indicating a moderately strong and statistically significant relationship between the two assets. To support investment decision-making, the multi-criteria decision-making method TOPSIS was applied, enabling the evaluation and ranking of various investment instruments according to the preferences of conservative and risk-oriented investors.

**Findings & Value added:** The findings highlight significant differences between the analysed assets in terms of volatility, return potential, and behaviour during different phases of the economic cycle. Gold shows the characteristics of a safe-haven asset, while the S&P 500 index appears more attractive for investors with a longer time horizon and higher risk tolerance. The added value of the study lies in its integration of quantitative analysis with behavioural aspects of investing and the implementation of multi-criteria decision-making as a tool for personalized investment recommendations. The study also opens space for future research focused on dynamic correlation models and the inclusion of other asset classes and investor profiles.

**Keywords:** investment; S&P index; gold; portfolio; TOPSIS

**JEL Classification:** C44; D81; G11

## 1. Introduction

Currently, investment gold is considered a highly valuable financial as well as tangible asset over the long term. In the past, gold was used as a form of currency; today, it is rather viewed as a store of value (Barunik et al., 2016). Gold belongs to the commodity group, alongside other precious metals and oil. This group does not generate added value in the same way that various types of stocks or bonds do. Investors profit only if the price of gold increases due to rising future demand, allowing them to sell the commodity at a higher price than the original purchase price (Kazak et al., 2025).

There are various forms of investing in gold: physical gold (the most widespread form of investment in gold, such as purchasing coins, jewellery, or bullion bars); Gold Exchange-Traded Funds (ETFs) – a form of investment in which investors do not have to own physical gold; ETFs are traded on stock exchanges. Examples include GOLDBEES (Reliance Gold ETF), AXISGOLD (Axis Gold ETF), SBIGOLDETF (SBI Gold ETF); Gold Mutual Funds – mutual funds that invest in physical gold and ETF funds. Currently, investors prefer to invest primarily in gold ETFs and gold mutual funds, which represent indirect investments in gold. This method is preferred mainly because investors can participate in the market without the need to physically own gold (Nawaz and Sudindra, 2013).

Gold is considered an investment tool that provides security to investors, especially due to market instability (the mismatch between supply and demand). The supply of gold is limited, while demand is either stable or constantly growing. This relationship leads to an increase in gold prices (Verma and Dhiman, 2020).

Investing in gold is especially suitable as an alternative for minimizing risk. Gold prices are relatively stable compared to stocks, which can fluctuate daily. Another reason for investing in gold is inflation protection. When interest rates rise and the value of the dollar falls, the price of gold tends to remain relatively stable. During the financial crisis between 2007 and 2009, the price of gold rose while the S&P 500 stock index declined. In 2008, at the peak of the crisis, gold increased by 4.32%, whereas the S&P 500 experienced a drop of as much as 37% (Choudhry et al., 2015).

The price development of gold since 2000 can be observed in Figure 1, which shows its evolution up to the present day.



Source: *finance.yahoo.com*

Stocks can be characterized as a type of equity security that entitles the shareholder (holder) to participate in the management of a joint-stock company. In addition to this right, they are entitled to a portion of the profit in the form of dividends. Stocks play a key role in the capital market, where they are the most widespread (Vojtekova et al., 2025). Stocks are generally bought and sold on stock exchanges, each of which has different trading hours. For stock investing to be successful, market knowledge is crucial. The price of a stock changes based on

supply and demand: demand consists of investors wanting to buy, and supply of those wanting to sell. When more investors want to sell, stock prices fall; conversely, when more investors want to buy, prices rise. Other factors also influence stock value, such as production expansion, a company's financial performance, international expansion, and more (Pietrucha and Maciejewski, 2024). The S&P 500 stock index, also known as the Standard & Poor's 500, includes the shares of 500 American companies. These stocks are traded on exchanges such as the New York Stock Exchange and NASDAQ. The index is regarded as an indicator of the performance of the U.S. economy. The S&P 500 consists of companies from 11 sectors, with the largest representation in information technology, healthcare, and consumer goods (Maghyereh et al., 2025). As shown in Table 1, the company with the greatest weight in the index is Apple, followed by Nvidia and Microsoft.

*Table 1: S&P companies*

| <b>Company</b>        | <b>Symbol</b> | <b>Weight (%)</b> |
|-----------------------|---------------|-------------------|
| Apple Inc.            | AAPL          | 6.76              |
| Nvidia Corp           | NVDA          | 6.04              |
| Microsoft Corp        | MSFT          | 6.00              |
| Amazon.com Inc        | AMZN          | 3.87              |
| Meta Platforms, Inc   | META          | 2.74              |
| Alphabet Inc. Class A | GOOGL         | 2.03              |
| Berkshire Hathaway    | BRK.B         | 1.97              |
| Broadcom Inc.         | AVGO          | 1.91              |
| Alphabet Inc. Class C | GOOG          | 1.67              |
| TESLA, Inc.           | TSLA          | 1.43              |

*Source: authors according to slickcharts.com (2025)*

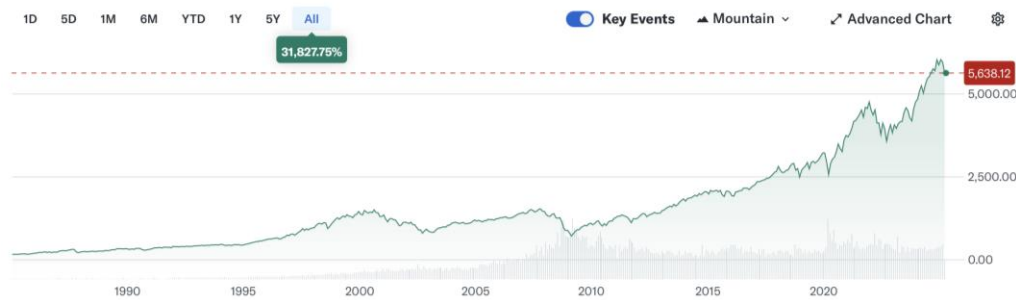
The performance of the S&P 500 index is influenced by various factors, such as technological innovations, macroeconomic factors, and market dynamics. A key role is played by exogenous factors, such as geopolitical events and technological changes, which affect the profitability of the index. Macroeconomic factors also play a significant role in the progression of the S&P 500. Among the most important macroeconomic indicators are interest rates, inflation, unemployment, and gross domestic product (GDP). The S&P 500 holds a dominant position and can influence the overall market condition when significant changes occur.

The most notable declines in the index were observed during the global financial crisis between 2007–2008 and at the onset of the COVID-19 pandemic in the years 2020–2021. During these crisis periods, significant volatility was recorded, driven by a combination of external factors. Strict regulations implemented during the COVID-19 pandemic negatively impacted sectors that are part of the S&P 500. Central banks eased monetary policy, aiming to increase market liquidity and stability by lowering interest rates. During this time, governments sought to provide support to individuals and businesses through fiscal measures. The pandemic heightened uncertainty among investors, which led to increased volatility (Nagy et al., 2024).

The development of the S&P 500 stock index from 1980 to the present is illustrated in Figure 2, showing long-term growth despite temporary fluctuations.

Comparative analysis of gold price development and the S&P 500 index plays a key role in understanding financial market behaviour and optimizing investment decisions. Gold and the S&P 500 represent two fundamentally different approaches to capital allocation (Nagy et al., 2024). While gold has traditionally been viewed as a store of value and a hedge against inflation and geopolitical tension, the S&P 500 index reflects a dynamic, growth-oriented segment of the market, representing the performance of 500 of the largest publicly traded companies in the United States (Triki and Maatoug, 2021). The distinct nature of these assets is evident in their historical development, volatility, returns, and their respective reactions during periods of crisis and expansion (Muguto and Muzindutsi, 2022).

*Figure 2: S&P 500 Index Price Development*



Source: *finance.yahoo.com* (2025)

From the turn of the millennium to 2024, several critical events have highlighted the divergence between gold and equities. During the bursting of the tech bubble in 2000, investors began shifting from riskier assets into safer havens, which led to a gradual increase in gold prices. Between 2007 and 2009, during the global financial crisis, the S&P 500 index plummeted by more than 50% of its value, while gold continued its ascent, culminating in a historic peak of over \$1,900 per ounce in 2011. This trend reinforced gold's role as a capital preservation tool during times of uncertainty (Mohammed et al., 2024).

Conversely, in the post-crisis recovery period after 2012, and especially during the bull market from 2013 to 2019, the S&P 500 experienced exceptional growth. This expansion was driven by accommodative monetary policy, technological innovation, and increasing investor appetite for risk. During these years, S&P 500 returns far outpaced those of gold. In 2020, however, the COVID-19 pandemic led to a short-term market downturn and a renewed surge in gold prices, which reached a new all-time high of over \$2,070 per ounce in August 2020. This again underscored gold's perceived safety during systemic risk events (Bircea and Popa, 2025).

Following the pandemic, stock markets rebounded rapidly thanks to aggressive stimulus measures, with the S&P 500 reaching new records in 2021. In contrast, gold prices stagnated and even declined slightly, largely due to rising interest rates and a strengthening U.S. dollar. In 2022, amid high inflation and geopolitical tension following Russia's invasion of Ukraine, demand for gold increased once again. Nonetheless, the combined strength of the technology sector and robust consumer demand helped maintain the S&P 500's position as a dominant source of returns over the medium term (Cardillo and Basso, 2025).

From a quantitative perspective, comparing average annual returns reveals that the S&P 500 has delivered about 8–10% per year (including dividends) over the past two decades, whereas gold has averaged around 5–6%. However, performance differences are significantly influenced by market timing and macroeconomic conditions (Doeswijk et al., 2020). Gold also exhibits lower correlation with the stock market, making it an important diversification tool. While its volatility is lower than that of equities, gold may underperform over long periods of economic growth, as it does not provide any regular income, such as dividends or interest.

From the standpoint of investment decision-making, it is crucial to consider these differences in a broader context. Gold should not be viewed as a competitor to stocks but rather as a complementary asset. Especially during times of anticipated recession, rising inflation, or geopolitical instability, gold can stabilize portfolio value and mitigate losses from declining stock markets (Zhou and Liang, 2025). Conversely, during periods of strong economic growth, low inflation, and a favourable business environment, equities offer higher growth potential. Therefore, effective investment strategy lies not in favouring one asset over the other, but in

combining them wisely based on the investor's risk profile, investment horizon, and current macroeconomic signals (Vega-Gamez and Alonso-Gonzalez, 2024).

Modern portfolio management theories, such as Harry Markowitz's Modern Portfolio Theory, support the concept of diversification through combining assets with low correlation. In this regard, gold serves as a hedge against systemic risk, while the S&P 500 offers exposure to economic growth. In practice, it is recommended that gold make up 5–15% of a diversified portfolio, depending on the investor's preferences and risk perception (Ahmed et al., 2022). Dynamic investors with longer time horizons may prefer greater exposure to equities, whereas conservative investors or those nearing retirement may increase their allocation to defensive assets such as gold (Dima et al., 2025).

In conclusion, although gold and equities represented by the S&P 500 belong to two distinct asset classes, their combination can form a robust and stable portfolio resilient to market fluctuations while offering attractive return potential. The choice between them should never be based on a “one-or-the-other” dichotomy, but rather on a rational and strategic assessment of current conditions and individual investment goals. In a changing world where uncertainty often dominates financial markets, diversification remains one of the few true forms of protection for investment capital.

## **2. Methodology**

There are many comparative analyses that allow us to evaluate various indicators. For the purpose of comparing investment instruments, specifically, examining gold and stocks in the context of investment decision-making, we have chosen to use the TOPSIS method.

The TOPSIS method is one of the most effective multi-criteria decision-making techniques, particularly due to its high consistency and relatively low computational complexity. This approach is based on combining multiple values in order to derive a single result (Madanchian and Taherdoost, 2023).

TOPSIS is characterized as a comparative method that assesses all alternatives based on their distance from an ideal solution, which represents hypothetical options offering maximum benefit at the lowest cost. The opposite of the ideal solution is a scenario where maximum costs are incurred without achieving sufficient benefits (Juracka et al., 2024).

In this case, when applying the TOPSIS method, we compare gold with three different types of stocks that vary across different parameters. As shown in Table 3, which presents the initial decision matrix, we selected, besides the already mentioned S&P 500 index which includes the 500 largest publicly traded companies in the United States, the dividend-focused stock VYM (Vanguard High Dividend Yield ETF). This ETF is characterized by investing in companies that pay high dividends. VYM is an exchange-traded fund comprising over 500 large-cap U.S. companies. These companies are primarily active in the financial, industrial, and consumer staples sectors. The main advantage of this fund is the stable income it provides, as the individual companies tend to have high yields and a broad sectoral focus.

As the final alternative, we selected the NASDAQ Composite stock index, which is among the most well-known stock indices alongside the S&P 500. It primarily includes companies focused on information technology. The NASDAQ Composite Index consists of over 3,700 companies, all of which are traded on the NASDAQ exchange. The index is dominated by companies such as Apple, Microsoft, Alphabet, and Meta. These firms are among the largest in terms of market capitalization and, due to their significant representation in the index, they have the greatest influence on the overall performance of the investment (Nagy et al., 2025).

Table 2: Basic matrix

|                  | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|------------------|----------------|-----------------|--------------------------|--------------|
| Gold             | 16.55          | 155,560         | 7.70                     | 0.38         |
| S&P 500          | 18.21          | 3,386,529       | 10.43                    | 0.65         |
| VYM              | 10.10          | 1,107,384       | 9.77                     | 0.25         |
| NASDAQ Composite | 22.98          | 6,411,941       | 19.7                     | 0.78         |

Source: own elaboration according to *finance.yahoo.com* (2025)

In Table 2, we can see the four criteria by which the alternatives were compared. Volatility is expressed as a percentage and is understood as the speed at which the price changes—the lower the volatility, the smaller the price fluctuations (Gupta and Mishra, 2024). The lowest volatility values are observed for the dividend stock VYM and gold, while the NASDAQ Composite index has the highest volatility. The next criterion we selected is liquidity. Among the chosen investment instruments, the NASDAQ Composite is the most liquid, with a value of USD 6,411,941. The average annual return is the penultimate criterion. Gold has the lowest return, at 7.70% annually. However, gold represents an investment that offers a consistently growing return over time for investors. The final criterion is the Sharpe ratio, which measures the performance of an investment in relation to its risk (Auer and Schuhmacher, 2013). The lowest Sharpe ratio is found in the dividend stock VYM, followed by gold, then the S&P 500, with the NASDAQ Composite showing the highest Sharpe ratio. The next step in the TOPSIS method is to create the Saaty matrix to obtain normalized weights. In the Saaty matrix, the criteria are compared with each other and individual preferences are selected. We selected two types of investors: a conservative investor and a risk-seeking investor. The conservative investor prefers minimizing risk, stability, and liquidity, while the risk-seeking investor is inclined toward higher returns and is willing to accept higher risk. Due to these differing investment strategies and preferences, we created two separate matrices in order to more accurately determine which investment instruments would be more suitable for each type of investor.

### 3. Results and Discussion

The first Saaty matrix was constructed for the risk-seeking investor. Based on Table 3, we calculated the geometric mean. The sum of the normalized weights should always equal 1.

Table 3: Saaty matrix (risk-seeking investor)

|                      | Volatility | Liquidity | Average annual yield | Sharpe ratio | Geometric mean | Standard weights |
|----------------------|------------|-----------|----------------------|--------------|----------------|------------------|
| Volatility           | 1          | 1/5       | 3                    | 3            | 1.16           | 0.184            |
| Liquidity            | 5          | 1         | 9                    | 7            | 4.21           | 0.668            |
| Average annual yield | 1/3        | 1/9       | 1                    | 3            | 0.58           | 0.092            |
| Sharpe ratio         | 1/3        | 1/7       | 1/3                  | 1            | 0.35           | 0.056            |
| Total                |            |           |                      |              | 6.30           | 1.00             |

Source: own elaboration

The next step was the creation of the criteria matrix (Table 4), where we defined the maximization and minimization criteria. Volatility is the only minimization criterion. Liquidity, average annual return, and the Sharpe ratio are considered maximization criteria.

Table 5 presents the transposed matrix, where the minimization criteria are converted into maximization criteria by subtracting all other values from the highest value.

Using the values in the transposed matrix, we can create a normalized matrix, which is calculated in Table 6.

Table 4: Criterion matrix (risk-seeking investor)

|                  | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|------------------|----------------|-----------------|--------------------------|--------------|
| Gold             | 16.55          | 155,560         | 7.70                     | 0.38         |
| S&P 500          | 18.21          | 3,386,529       | 10.43                    | 0.65         |
| VYM              | 10.10          | 1,107,384       | 9.77                     | 0.25         |
| NASDAQ Composite | 22.98          | 6,411,941       | 19.7                     | 0.78         |

Source: own elaboration

Table 5: Transpose matrix (risk-seeking investor)

|                  | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|------------------|----------------|-----------------|--------------------------|--------------|
| Gold             | <b>6.43</b>    | 155,560         | 7.70                     | 0.38         |
| S&P 500          | <b>4.77</b>    | 3,386,529       | 10.43                    | 0.65         |
| VYM              | <b>12.88</b>   | 1,107,384       | 9.77                     | 0.25         |
| NASDAQ Composite | <b>0.00</b>    | 6,411,941       | 19.70                    | 0.78         |

Source: own elaboration

Table 6: Normalized matrix (risk-seeking investor)

|                  | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|------------------|----------------|-----------------|--------------------------|--------------|
| Gold             | 0.424          | 0.021           | 0.302                    | 0.342        |
| S&P 500          | 0.315          | 0.462           | 0.409                    | 0.584        |
| VYM              | 0.849          | 0.151           | 0.383                    | 0.225        |
| NASDAQ Composite | 0.000          | 0.874           | 0.772                    | 0.701        |

Source: own elaboration

The final step before calculating the ideal and basal variant is the computation of the normalized weights for each criterion. This matrix is called the weighted matrix (Table 7). The normalized weights for the criteria are obtained by multiplying all values in the normalized matrix by the corresponding weight of each criterion. The values for volatility are multiplied by a weight of 0.184, liquidity by 0.668, average annual return by 0.092, and the Sharpe ratio by 0.056.

Table 7: Weighted matrix (risk-seeking investor)

| Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|----------------|-----------------|--------------------------|--------------|
| 0.184          | 0.668           | 0.092                    | 0.056        |
| 0.078          | 0.014           | 0.028                    | 0.019        |
| 0.058          | 0.308           | 0.037                    | 0.033        |
| 0.156          | 0.101           | 0.035                    | 0.013        |
| 0.000          | 0.584           | 0.071                    | 0.039        |

Source: own elaboration

Then ideal and basal values are calculated; these values represent the highest (H) and lowest (D) value of each individual criterion (Table 8).

Table 8: Ideal and basal variants (risk-seeking investor)

|   | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|---|----------------|-----------------|--------------------------|--------------|
| H | 0.156          | 0.584           | 0.071                    | 0.039        |
| D | 0.000          | 0.014           | 0.028                    | 0.013        |

Source: own elaboration

The final step in the TOPSIS method is calculating the distance from the ideal variant (using the Euclidean distance measure). Based on the values of  $c$ , we determine the ranking of the individual alternatives. When the  $c$  value of a particular alternative is the highest, that alternative ranks first. The result of the TOPSIS method for a risk-seeking investor is shown in Table 9. The highest value of the  $c$  indicator was achieved by the NASDAQ Composite stock index, which means that for an investor seeking risk, the recommended investment is in

NASDAQ Composite stocks. Conversely, based on the given preferences, gold is the least attractive investment option.

Table 9: Calculation of distance (risk-seeking investor)

|                  | d+    | d-    | c     | Ranking |
|------------------|-------|-------|-------|---------|
| Gold             | 0.577 | 0.078 | 0.119 | 4       |
| S&P 500          | 0.295 | 0.301 | 0.505 | 2       |
| VYM              | 0.485 | 0.179 | 0.269 | 3       |
| NASDAQ Composite | 0.156 | 0.572 | 0.786 | 1       |

Source: own elaboration

Since we are primarily comparing the S&P 500 stock fund and gold, Table 10 shows that the value of the c indicator for the S&P 500 is 0.505, while for gold it is 0.119. This implies that for an investor inclined toward risk, the recommended investment is primarily in the S&P 500 stock fund.

The Saaty matrix also serves as a tool for calculating the consistency ratio. The consistency of the matrix is assessed based on the preferences of a risk-seeking investor by multiplying the Saaty matrix by the corresponding weight vector. The higher the Consistency Index (CI) value, the greater the deviation from consistency. A value closer to zero indicates a higher level of consistency. The results of this calculation are recorded in Table 10, which is further used in the next steps of the analysis.

Table 10: The result of multiplying the matrix by the corresponding vector (risk-seeking investor)

|       |       |       |       | Result |
|-------|-------|-------|-------|--------|
| 0.041 | 0.079 | 0.017 | 0.051 | 0.188  |
| 0.286 | 0.551 | 0.757 | 0.772 | 2.365  |
| 0.370 | 0.110 | 0.150 | 0.090 | 0.715  |
| 0.200 | 0.180 | 0.450 | 0.260 | 1.099  |

Source: own elaboration

To obtain the value of the consistency ratio (CR), we calculate the ratio between the consistency index and the random consistency index. Since we are considering four criteria in our case, we used a random consistency index value of 0.089. The calculated CR value was 0.092, which means that our comparison is consistent. If the consistency ratio  $CR \leq 0.10$ , the matrix can be considered sufficiently consistent; otherwise, it is necessary to reconsider the weighting comparison among the criteria.

We also applied the TOPSIS method for a conservative investor in order to determine which investment instruments would be most suitable for them based on the results. We used the basic matrix, which defines all the values for the individual alternatives.

To obtain the normalized weights, we created a Saaty matrix where we applied preferences that would typically be characteristic of a conservative investor. All the preferences, followed by the calculation of the geometric mean and normalized weights, are recorded in Table 11, where the total geometric mean came out to be 6.16. The normalized weights, which we will use in the later calculations, were as follows: for volatility 0.588, for liquidity 0.041, for average annual return 0.111, and for Sharpe ratio 0.237.

In the next step, we constructed the criteria matrix. We followed the same procedure as with the investor inclined toward risk, identifying both maximization and minimization criteria. Since we are working with the same set of criteria, the only minimization criterion is volatility. All the results were recorded in the following Table 12.

Table 11: Saaty matrix (conservative investor)

|                      | Volatility | Liquidity | Average annual yield | Sharpe ratio | Geometric mean | Standard weights |
|----------------------|------------|-----------|----------------------|--------------|----------------|------------------|
| Volatility           | 1          | 9         | 7                    | 3            | 3.71           | 0.602            |
| Liquidity            | 1/9        | 1         | 1/5                  | 1/5          | 0.26           | 0.042            |
| Average annual yield | 1/7        | 5         | 1                    | 1/3          | 0.70           | 0.113            |
| Sharpe ratio         | 1/3        | 5         | 3                    | 1            | 1.50           | 0.243            |
| Total                |            |           |                      |              | 6.16           | 1.0              |

Source: own elaboration

Table 12: Criterion matrix (conservative investor)

|                  | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|------------------|----------------|-----------------|--------------------------|--------------|
| Gold             | 16.55          | 155,560         | 7.70                     | 0.38         |
| S&P 500          | 18.21          | 3,386,529       | 10.43                    | 0.65         |
| VYM              | 10.10          | 1,107,384       | 9.77                     | 0.25         |
| NASDAQ Composite | 22.98          | 6,411,941       | 19.7                     | 0.78         |

Source: own elaboration

The criteria matrix serves as an intermediate step in the creation of the transposed matrix. In the transposed matrix, for the minimization criterion, we subtract all other values of the individual criterion from the highest value. This gives us Table 13 with the new values of the individual alternatives.

Table 13: Transpose matrix (conservative investor)

|                  | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|------------------|----------------|-----------------|--------------------------|--------------|
| Gold             | 6.43           | 155,560         | 7.70                     | 0.38         |
| S&P 500          | 4.77           | 3,386,529       | 10.43                    | 0.65         |
| VYM              | 12.88          | 1,107,384       | 9.77                     | 0.25         |
| NASDAQ Composite | 0.00           | 6,411,941       | 19.70                    | 0.78         |

Source: own elaboration

As we defined the calculation of the normalized matrix for the risk-seeking investor, we followed the same procedure for the conservative investor. Through this calculation, we obtained the normalized matrix (Table 14).

Table 14: Normalized matrix (conservative investor)

|                  | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|------------------|----------------|-----------------|--------------------------|--------------|
| Gold             | 0.42           | 0.02            | 0.30                     | 0.34         |
| S&P 500          | 0.31           | 0.46            | 0.41                     | 0.58         |
| VYM              | 0.85           | 0.15            | 0.38                     | 0.22         |
| NASDAQ Composite | 0.00           | 0.87            | 0.77                     | 0.70         |

Source: own elaboration

The normalized weights obtained from Table 13 are used in the calculation of the following Table 15. The values in the table are derived by multiplying the normalized weights of each criterion by the corresponding values from the normalized matrix. The weights used for the multiplication are as follows: volatility (0.588), liquidity (0.041), average annual return (0.111), and Sharpe ratio (0.237).

Table 15: Weighted matrix (conservative investor)

| Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|----------------|-----------------|--------------------------|--------------|
| 0.602          | 0.042           | 0.113                    | 0.243        |
| 0.255          | 0.001           | 0.034                    | 0.083        |
| 0.189          | 0.019           | 0.046                    | 0.142        |
| 0.511          | 0.006           | 0.043                    | 0.055        |
| 0.000          | 0.036           | 0.088                    | 0.170        |

Source: own elaboration

We continue with the calculation of the ideal and baseline variants for each criterion, which means identifying the maximum (H) and minimum (D) values from the weighted matrix for the conservative investor. All values are recorded in Table 16.

Table 16: Ideal and basal variants (conservative investor)

|   | Volatility (%) | Liquidity (USD) | Average annual yield (%) | Sharpe ratio |
|---|----------------|-----------------|--------------------------|--------------|
| H | 0.5112         | 0.0366          | 0.0875                   | 0.1702       |
| D | 0.0000         | 0.0009          | 0.0342                   | 0.0545       |

Source: own elaboration

To determine the final ranking of investment instruments for a conservative investor, we need to calculate the distances from the ideal and nadir solutions. We recalculated the values of  $d^+$  and  $d^-$ , which are necessary for computing the indicator  $c$ . The values of  $c$  for each instrument are as follows: gold 0.480, S&P 500 0.391, VYM 0.801, and NASDAQ Composite 0.206. According to this calculation, it is clear that a conservative investor is advised to invest in the dividend stock VYM and gold, which ranks second, as shown in Table 17. For the conservative investor, the NASDAQ Composite stock index is the least preferred option.

When comparing the S&P 500 stock index and gold, based on the ranking, it can be concluded that gold is the primary recommended investment for a conservative investor.

Table 17: Calculation of distance (conservative investor)

|                  | $d^+$ | $d^-$ | $c$   | Ranking |
|------------------|-------|-------|-------|---------|
| Gold             | 0.278 | 0.257 | 0.480 | 2       |
| S&P 500          | 0.326 | 0.210 | 0.391 | 3       |
| VYM              | 0.127 | 0.511 | 0.801 | 1       |
| NASDAQ Composite | 0.511 | 0.132 | 0.206 | 4       |

Source: own elaboration

To verify the pairwise comparison in the Saaty matrix, we calculate the consistency ratio. All calculations and results are recorded in Table 18.

Table 18: The result of multiplying the matrix by the corresponding vector (conservative investor)

|       |       |       |       | Result |
|-------|-------|-------|-------|--------|
| 0.602 | 0.377 | 0.794 | 0.728 | 2.501  |
| 0.067 | 0.042 | 0.023 | 0.049 | 0.180  |
| 0.086 | 0.210 | 0.113 | 0.081 | 0.490  |
| 0.201 | 0.210 | 0.340 | 0.243 | 0.993  |

Source: own elaboration

We proceed in the same way as with the investor inclined toward risk. We calculate the value of the indicator  $\lambda_{\max}$ . The calculation yielded the value 4.215. Next, we calculate the inconsistency index, which gave us a value of 0.072, and then the consistency ratio (CR). Since we are considering four criteria for the conservative investor, we again used the value of the random consistency index 0.089. The CR calculation resulted in a value of 0.080. Based on this result, we conclude that our comparison is consistent.

Based on the calculations from the TOPSIS analysis for the selected types of investors, we can assess that the comparisons align with expectations. These results can assist in investment decision-making and portfolio construction, helping to guide investors toward specific investments. When comparing the S&P 500 index and gold, we can conclude from the TOPSIS results that, based on preferences, a conservative investor is recommended to invest in gold, while an investor who prefers risk is advised to invest in the S&P 500 index.

In addition, we collected historical price data for gold and the S&P 500 index on a daily basis from February 2015 to 2025 (Figure 3), in order to map the development of both

instruments over the past 10 years. Using this data, we created Figure 3, which illustrates the growth and decline of these investment tools in different periods.

*Figure 3: The price trends of gold and S&P 500 index*



*Source: own elaboration*

A significant drop in the S&P 500 index during the observed period can be seen especially in the year 2020, when the COVID-19 pandemic prevailed globally. This pandemic triggered a global crisis that affected the economies of all countries and also had a substantial impact on the stock market (Zhang et al., 2020). Based on the research of Pekar et al. (2022), it is clear that COVID-19 caused declines in various investments and also negatively affected stock markets. During this period, the S&P 500 adjusted its investment strategy to mitigate further losses by reallocating investments primarily into sectors such as healthcare, information technology, and communication services. As a result, the portfolio during this time had increased allocations to stocks like NVIDIA, Netflix, AbbVie, Regeneron, etc. Currently, the portfolio composition of the S&P 500 is significantly different.

In 2022, we observed another decline in the index, which, according to Sharif et al. (2025), was caused by the tightening of monetary policy, leading to interest rate hikes. Other contributing factors to this downturn included inflation and geopolitical uncertainties such as the Russia–Ukraine conflict, which caused a rapid surge in energy prices, thereby increasing inflation and creating further uncertainty in the stock markets. From the end of 2023 onward, we have been observing a growing trend in the S&P 500 index.

In Figure 3, we can also observe the development of gold prices. From 2015 to 2020, gold experienced only a modest increase, which could be attributed to low inflation in the United States and low interest rates. There was no significant price expansion of gold during this period; on the contrary, prices remained relatively flat. A turning point came in 2020 with the outbreak of the pandemic (Valadkhani et al., 2022). COVID-19 had the opposite effect on gold prices compared to the S&P 500 index. Investors began investing more in safe-haven assets such as gold, primarily due to uncertainty. This rise in gold prices was further supported by inflation and monetary policy. After this period, the price stabilized until 2022, when gold prices began rising again. This increase was caused by the outbreak of war, during which

investors began to prefer gold over equity funds. The war was also accompanied by rising inflation, which especially influenced the increased volatility and rising gold prices (Morina et al., 2024).

When comparing investment tools such as gold and the S&P 500, it becomes evident that global crises, pandemics like COVID-19, or geopolitical conflicts have different impacts on their price developments. Gold is often seen as a hedge against inflation, and investors tend to favour it in times of crisis, as it represents a form of safety. Conversely, during such periods, investors tend to sell off S&P 500 stocks due to their decreasing value. However, investors should remain persistent even in these times, as such assets usually regain value after a certain period.

Based on the summarized data, we analysed the relationship between the selected investment tools using correlation analysis. Specifically, we applied the Pearson correlation coefficient. This analysis investigates the dependency between variables, in this case, the price development of both monitored instruments. The results we obtained are presented in Table 19.

*Table 19: Correlation analysis*

|                   |                     | <b>S&amp;P500</b> | <b>Gold</b> |
|-------------------|---------------------|-------------------|-------------|
| <b>S&amp;P500</b> | Pearson Correlation | 1                 | 0.513       |
|                   | Sig. (2-tailed)     |                   | 0.000       |
|                   | N                   | 60                | 60          |
| <b>Gold</b>       | Pearson Correlation | 0.513             | 1           |
|                   | Sig. (2-tailed)     | 0.000             |             |
|                   | N                   | 60                | 60          |

*Source: own elaboration*

The correlation was calculated based on 2,516 data points representing the development of the gold price and the S&P 500 index from February 2015 to February 2025. We tested the null hypothesis that the correlation coefficient can be considered zero, meaning the variables are linearly independent. This hypothesis was tested at a significance level of 0.05. Given that the p-value of this test is zero (i.e., the p-value is less than the chosen significance level), the null hypothesis is rejected in favour of the alternative hypothesis, which states that the correlation between the variables is non-zero and the variables are linearly dependent. The value of 0.513 for the Pearson correlation coefficient indicates that there is a moderate statistically significant relationship between the variables. The selected investment instruments show a moderate degree of dependence, not a strong one, primarily due to differing reactions to market changes (Keelson et al., 2024). When constructing an investment portfolio, it would be appropriate to include both instruments, particularly to balance risk and return. For investors, this combination could provide stable returns even over the long term.

A comparison of two types of investors shows that investment decision-making is largely determined by the individual's attitude toward risk, investment horizon, and expectations regarding returns and stability (Lee et al., 2015). While a risk-oriented investor tends to favour assets with higher volatility and return potential, a conservative investor prefers instruments that offer lower returns but are less susceptible to market fluctuations. This polarization in preferences translates into completely different investment recommendations, even when evaluating the same financial instruments—for instance, while one investor may find the S&P 500 index attractive due to its returns and liquidity, another may find it less suitable due to the volatility perceived as risky (Omanovic and Zaimovic, 2024). Conversely, gold, as a traditional store of value, may represent a safe haven for a conservative investor but may offer too little growth potential for a more dynamically oriented one.

A general comparison between gold and the S&P 500 index reveals fundamental differences between the two assets in terms of their characteristics, behaviour in various phases of the

economic cycle, and levels of risk and return (Golitsis et al., 2022). Gold has historically been perceived as a safe asset, serving primarily as a protection of wealth during periods of uncertainty, inflation, or geopolitical tension. Its value is less dependent on the performance of individual companies or economic sectors and therefore often functions as a "safe haven" during crises (Gajdosikova and Vojtekova, 2024). On the other hand, the S&P 500 index is a composite indicator of the performance of the 500 largest publicly traded companies in the U.S., reflecting broader economic trends and stock market sentiment. Although its performance is more volatile, it shows a higher average return than gold over the long term, making it an attractive option for investors with a longer investment horizon and a higher tolerance for risk (Rehman et al., 2025).

These differences are also reflected in their correlation, while the S&P 500 is closely tied to cyclical factors, gold tends to move inversely to stock markets during downturns, making it a suitable tool for portfolio diversification. From this, it follows that neither of these assets can be objectively labelled as better or worse, their suitability depends on the investment strategy, macroeconomic outlook, and the personal investment profile of the individual (Dwivedi et al., 2022).

This contrast highlights the importance of personalized investment advice and decision-making, which should not be based solely on objective performance indicators but, above all, on a thorough understanding of the investor's individual profile (Luo et al., 2024). In this context, multi-criteria decision-making methods such as Analytic Hierarchy Process and Technique for Order Preference by Similarity to Ideal Solution appear to be appropriate and effective tools, allowing the consideration of multiple criteria simultaneously and weighting them according to specific investor preferences. Their use not only systematizes the decision-making process but also increases its transparency and repeatability, which is extremely valuable in the context of investment planning (Marciniak and Stanislawski, 2021).

At the same time, this analysis shows that there is no universally best investment, each decision depends on specific circumstances and preferences. For this reason, it is important that investors (whether individuals or institutions) have access to tools that allow them to quantify their expectations and priorities and thus obtain recommendations that are truly tailored. In a time when financial markets are facing constant uncertainty and dynamic changes, the ability to adapt investment strategies to individual needs becomes one of the key advantages in achieving long-term financial success (Ledesma-Chaves and Arenas-Gaitan, 2023).

#### **4. Conclusions**

This comparative analysis of gold and the S&P 500 index highlights the fundamentally different roles these two assets play in investment decision-making. While gold is traditionally viewed as a safe haven and a store of value, especially in times of economic uncertainty, the S&P 500 index reflects broader market sentiment and offers higher return potential over the long term—albeit with greater volatility. The moderate but statistically significant correlation between these assets confirms that, despite some level of co-movement, they respond differently to macroeconomic conditions and can thus complement each other in a diversified investment portfolio.

From a theoretical standpoint, the study underscores the importance of aligning investment choices with individual investor profiles, particularly with respect to risk tolerance, investment horizon, and return expectations. It also supports the use of multi-criteria decision-making methods such as AHP and TOPSIS, which enable a systematic and transparent evaluation of investment alternatives based on personalized preferences. This approach bridges traditional

financial analysis with behavioural finance, highlighting the necessity of integrating subjective factors into portfolio construction.

However, the analysis also has certain limitations. It relies on historical data from 2015 to 2025, which may not fully capture future dynamics or structural breaks caused by unforeseen global events. The correlation analysis, while informative, only reveals linear relationships and does not account for potential non-linear dependencies or time-varying interactions between gold and equity markets. Furthermore, investor behaviour was considered in a simplified binary typology (risk-seeking vs. conservative), which may not reflect the full diversity of real-world investor preferences.

Future research could expand on these findings by incorporating non-linear and time-series models (e.g., DCC-GARCH) to examine dynamic correlations over time. Moreover, integrating additional asset classes, such as bonds, cryptocurrencies, or real estate, could provide a more comprehensive view of portfolio diversification strategies. Finally, experimental and behavioural studies that explore how individual investors use tools like AHP or TOPSIS in real decision-making contexts would offer valuable insights into the practical applicability of these methods in financial advisory and planning.

In sum, the comparative analysis confirms that neither gold nor the S&P 500 is universally superior; their utility depends on contextual and personal factors. Therefore, modern investment strategies must emphasize customization, flexibility, and a holistic understanding of both quantitative and qualitative decision-making dimensions.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Ahmed, Z., Rasool, S., Saleem, Q., Ali Khan, M., & Kanwal, S. (2022). Mediating Role of Risk Perception Between Behavioral Biases and Investor's Investment Decisions. *SAGE Open*, 12(2). <https://doi.org/10.1177/21582440221097394>
- Auer, B.R., & Schuhmacher, F. (2013). Performance hypothesis testing with the Sharpe ratio: The case of hedge funds. *Finance Research Letters*, 10(4), 196-208. <https://doi.org/10.1016/j.frl.2013.08.001>
- Barunik, J., Kocenda, E., & Vacha, L. (2016). Gold, oil, and stocks: Dynamic correlations. *International Review of Economics & Finance*, 42, 186-201. <https://doi.org/10.1016/j.iref.2015.08.006>
- Bircea, I., & Popa, D.R. (2025). Comparative Analysis of Returns on the Capital Market Versus the Real Estate Market in Romania. *Acta Marisiensis. Seria Oeconomica*, 18, 107. <https://doi.org/10.62838/amso-2024-0009>
- Cardillo, M.A., & Basso, L.F.C. (2025). Revisiting knowledge on ESG/CSR and financial performance: A bibliometric and systematic review of moderating variables. *Journal of Innovation & Knowledge*, 10(1), 100648. <https://doi.org/10.1016/j.jik.2024.100648>
- Choudhry, T., Hassan S.S., & Shabi, S. (2015). Relationship between gold and stock markets during the global financial crisis: Evidence from nonlinear causality tests. *International Review of Financial Analysis*, 41, 247-256. <https://doi.org/10.1016/j.irfa.2015.03.011>
- Dima, B., Dima, S.M., & Ioan, R. (2025). The short-run impact of investor expectations' past volatility on current predictions: The case of VIX. *Journal of International Financial Markets, Institutions and Money*, 98, 102084. <https://doi.org/10.1016/j.intfin.2024.102084>
- Doeswijk, R., Lam, T., & Swinkels, L. (2020). Historical returns of the market portfolio. *The Review of Asset Pricing Studies*, 10(3), 521-567. <https://doi.org/10.1093/rapstu/raz010>

- Dwivedi, Y.K., Hughes, L., Baabdullah, A.M., Ribeiro-Navarette, S., Giannakis, M., Al-Debei, M.M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C.M., Canboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D.P., Gustafsson, A., Hinsch, C., Jebabli, I., Janssen, M., & Wamba, S.F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, 66, 102524. <https://doi.org/10.1016/j.jinfomgt.2022.102542>
- Gajdosikova, D., & Vojtekova, S. (2024). Comparative Analysis of Business Environment Dynamics in Central and Eastern Europe: A Multi-Criteria Approach. *Economies*, 12(12), 320. <https://doi.org/10.3390/economies12120320>
- Golitsis, P., Gkasis, P., & Bellos, S.K. (2022). Dynamic spillovers and linkages between gold, crude oil, S&P 500, and other economic and financial variables. Evidence from the USA. *The North American Journal of Economics and Finance*, 63, 101785. <https://doi.org/10.1016/j.najef.2022.101785>
- Gupta, A., & Mishra, R. (2024). A comprehensive study of stock market volatility: Types, determinants, and measurement methods. *International Journal For Multidisciplinary Research*, 6(6), 30054. <https://doi.org/10.36948/ijfmr.2024.v06i06.30054>
- Juracka, D., Nagy, M., Valaskova, K., & Nica, E. (2024). A Meta-Analysis of Innovation Management in Scientific Research: Unveiling the Frontier. *Systems*, 12(4), 130. <https://doi.org/10.3390/systems12040130>
- Kazak, H., Mensi, W., Gunduz, M.A., Kilicarslan, A., Akcan, A.T. (2025). Connections between gold, main agricultural commodities, and Turkish stock markets. *Borsa Istanbul Review*, 25(2), 296-310. <https://doi.org/10.1016/j.bir.2025.01.001>
- Keelson, S. A., Cug, J., Amoah, J., Petrakova, Z., Addo, J. O., & Jibril, A. B. (2024). The Influence of Market Competition on SMEs' Performance in Emerging Economies: Does Process Innovation Moderate the Relationship? *Economies*, 12(11), 282. <https://doi.org/10.3390/economies12110282>
- Ledesma-Chaves, P., & Arenas-Gaitan, J. (2023). Dynamic capabilities in times of economic crisis. A vision of success in international markets. *Heliyon*, 9(12), e22703. <https://doi.org/10.1016/j.heliyon.2023.e22703>
- Lee, B., Rosenthal, L., Veld, C., & Veld-Merkoulova, Y. (2015). Stock market expectations and risk aversion of individual investors. *International Review of Financial Analysis*, 40, 122-131. <https://doi.org/10.1016/j.irfa.2015.05.011>
- Luo, H., Liu, X., Lv, X., Hu, Y., & Ahmad, A.J. (2024). Investors' willingness to use robo-advisors: Extrapolating influencing factors based on the fiduciary duty of investment advisors. *International Review of Economics & Finance*, 94, 103411. <https://doi.org/10.1016/j.iref.2024.103411>
- Madanchian, M., & Taherdoost, H. (2023). A comprehensive guide to the TOPSIS method for multi-criteria decision making. *Sustainable Social Development*, 1(1), 2220. <https://doi.org/10.54517/ssd.v1i1.2220>
- Maghyreh, A., Al-Shboul, M., & Awartani, B. (2025). Gold-backed cryptocurrencies in cryptocurrency portfolios: Evaluating their hedging capabilities and safe-haven characteristics during extreme market conditions. *Oeconomia Copernicana*, 16, 317-388. <https://doi.org/10.24136/oc.3272>
- Marciniak, P., & Stanislawski, R. (2021). Internal Determinants in the Field of RPA Technology Implementation on the Example of Selected Companies in the Context of Industry 4.0 Assumptions. *Information*, 12(6), 222. <https://doi.org/10.3390/info12060222>
- Mohammed, A.E.A., Mwambi, H., & Omolo, B. (2024). Time-Varying Correlations between JSE.JO Stock Market and Its Partners Using Symmetric and Asymmetric Dynamic Conditional Correlation Models. *Stats*, 7, 761. <https://doi.org/10.3390/stats7030046>
- Morina, F., Misiri, V., Dinaj, S., & Grima, S. (2024). The impact of the COVID – 19 pandemic and the Russian invasion of Ukraine on gold markets. *Business management and economics engineering*, 22(1), 17-32. <https://doi.org/10.3846/bmee.2024.19799>
- Muguto, L., & Muzindutsi, P.-F. (2022). A Comparative Analysis of the Nature of Stock Return Volatility in BRICS and G7 Markets. *Journal of Risk and Financial Management*, 15(2), 85. <https://doi.org/10.3390/jrfm15020085>
- Nagy, M., Figura, M., Valaskova, K., & Lăzăroiu, G. (2025). Predictive maintenance algorithms, artificial intelligence digital twin technologies, and internet of robotic things in big data-driven industry 4.0 manufacturing systems. *Mathematics*, 13(6), 981. <https://doi.org/10.3390/math13060981>
- Nagy, M., Valaskova, K., Kovalova, E., & Macura, M. (2024). Drivers of S&P 500's profitability: Implications for investment strategy and risk management. *Economies*, 12(4), 77. <https://doi.org/10.3390/economies12040077>
- Nawaz, M.N. & Sudindra, V. R. (2013). A study on various forms of gild investment. *Asia Pacific Journal of Research*, 2(4), 55-70.

- Omanovic, A., & Zaimovic, A. (2024). The determinants of financial risk tolerance and portfolio allocation: Have the Covid-19 pandemic and the Ukraine war affected our risk tolerance? *Borsa Istanbul Review*, 24(6), 1381-1392. <https://doi.org/10.1016/j.bir.2024.11.001>
- Pekar, J., Brezina, I., & Reiff, M. (2022). Determining the investors' strategy during the COVID-19 crisis based on the S&P 500 stock index. *Strategic management*, 29(3), 28-42. <https://doi.org/10.5937/StraMan2200029P>
- Pietrucha, J., & Maciejewski, G. (2025). Precautionary cash holding by consumers making electronic payments and risk-taking behavior. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 19(4), 1273-1303. <https://doi.org/10.24136/eq.3073>
- Rehman, M.U., Nautiyal, N., & Vo, X.V. (2025). Is it just green? Asymmetry behavior of returns in green investments. *International Review of Economics & Finance*, 100, 104088. <https://doi.org/10.1016/j.iref.2025.104088>
- Sharif, T., Bouteska, A., Abedin, M.Z., & Cotturone, S. (2025). An enquiry into the monetary policy and stock market shocks in the US. *International Review of Economics & Finance*, 98, 103925. <https://doi.org/10.1016/j.iref.2025.103925>
- Triki, M.B. & Maatoug, A.B. (2021). The GOLD market as a safe haven against the stock market uncertainty: Evidence from geopolitical risk. *Resources Policy*, 70, 101872. <https://doi.org/10.1016/j.resourpol.2020.101872>
- Valadkhani, A., Nguyen, J., & Chiah, M. (2022). When is gold an effective hedge against inflation? *Resources Policy*, 79, 103009. <https://doi.org/10.1016/j.resourpol.2022.103009>
- Vega-Gamez, F., & Alonso-Gonzalez, P.J. (2024). How likely is it to beat the target at different investment horizons: an approach using compositional data in strategic portfolios. *Financial Innovation*, 10, 125. <https://doi.org/1186/s40854-023-00601-3>
- Verma, R., & Dhiman, D. (2020). A causal study on gold, SENSEX, and gold exchange traded funds. *Gold Bulletin*, 53, 121-128. <https://doi.org/10.1007/s13404-020-00280-3>
- Vojtekova, S., Miklusicakova, P., Krastev, V. & Durana, P. (2025). The effects of the COVID-19 pandemic on business activity indicators in the V4 region. *Journal of Business Sectors*, 3(1), 13–24. <https://doi.org/10.62222/AICG6810>
- Zhang, D., Hu, M., & Ji, Q. (2020). Financial markets under the global pandemic of COVID-19. *Finance Research Letters*, 36, 101528. <https://doi.org/10.1016/j.frl.2020.101528>
- Zhou, H., & Liang, C. (2025). Geopolitical risk and gold price bubbles. *Review of Accounting and Finance*, 24(3), 353-374. <https://doi.org/10.1108/RAF-09-2024-0369>

## FROM STRATEGY AND PRACTICE TO ORGANIZATIONAL SUCCESS IN INTERNATIONALIZATION: A QUALITATIVE APPROACH

Elena Adriana Biea<sup>1,a,\*</sup> and Victor Ciuciuc<sup>1,b</sup>

<sup>1</sup> 30A Expoziției Ave, Bucharest 012104, Romania

<sup>a</sup>adrianabiea@gmail.com, <sup>b</sup>emanuelciuciuc@gmail.com

\*Corresponding author

*Cite as:* Biea, E.-A, Ciuciuc, V. (2025). *From strategy and practice to organizational success in internationalization: A qualitative approach*, *Ekonomicko-manazerske spektrum*, 19(1), 55-68.

*Available at:* [dx.doi.org/10.26552/ems.2025.1.55-68](https://dx.doi.org/10.26552/ems.2025.1.55-68)

---

*Received:* 4 January 2025; *Received in revised form:* 17 April 2025; *Accepted:* 25 May 2025; *Available online:* 30 June 2025

### Abstract:

*Research background:* Digital transformation is recasting the logic of international expansion, yet the literature seldom analyses the mutually reinforcing effects of managerial practice and emergent technologies.

*Purpose of the article:* Building on semi-structured interviews with eleven senior managers drawn equally from SMEs and large corporations, this qualitative study examines how B2B strategic configurations, when mediated by digital tools, translate into competitive strength and, ultimately, superior organisational performance across borders.

*Methods:* Thematic analysis uncovers three interlocking mechanisms: (i) dynamic portfolio adaptation, enabling real-time alignment between product attributes and market micro-segments; (ii) data-enabled orchestration of global partnerships that compresses learning cycles and mitigates distance-related risk; and (iii) digitally-driven performance monitoring, which transcends conventional financial metrics by integrating customer-centric and sustainability indicators.

*Findings & Value added:* Moreover, the findings highlight the strategic salience of intangible digital assets, data-governance routines, analytics competencies and robust cyber-security protocols, in safeguarding reputation and unlocking cross-border synergies, a dimension rarely addressed in prior SME-centred work. When such digital capabilities are embedded in a coherent managerial vision, firms report markedly faster market entry, deeper customer penetration and sustained profitability; where technology is adopted as a mere operational bolt-on, performance spill-overs are largely absent. For practitioners and policy-makers, the study provides evidence-based guidance on designing integrated expansion road-maps that leverage digitalisation to enhance competitiveness and long-run performance in today's hyper-connected global economy. Future research can build upon this foundation by testing the model quantitatively across industries and institutional settings.

**Keywords:** competitiveness; digitalization; internationalization; organizational performance; managerial practices and strategies

**JEL:** M12

## **1. Introduction**

Research into internationalisation, and specifically the deployment of B2B managerial strategies and practices, is hardly new; yet this study seeks to offer a timely contribution by examining how organisational behaviour is being reshaped by digital transformation and emergent technologies.

Within the specialized literature the term internationalisation is typically employed in the strategy domain (Bi et al., 2024) to describe the staged, incremental process through which a firm moves beyond its domestic market and expands commercial activities abroad (Kessler and Zipper-Weber, 2023).

Over the past decade, investigating the global development of businesses has become imperative for organisations intent on sustaining competitive advantage (Vatamanescu et al., 2019), and scholarship has increasingly adopted holistic perspectives (Efrat et al., 2017; Du et al., 2023). For small and medium-sized enterprises (SMEs), crossing national borders and establishing an active presence in external markets are challenges that must be addressed judiciously (Arbelo et al., 2024; Vatamanescu et al., 2017, 2019, 2020a, 2020b, 2022). Concurrently, large firms have also been affected by the trend towards an open global position and have engaged in complex strategies to expand their operations in global markets (Anggara et al., 2025).

Companies seeking to enter new markets often adopt growth strategies and strengthen international B2B relationships. Research has detailed how certain growth strategies impact a firm's performance (Cha et al., 2023). Internationalization may involve partnering with strategic allies to share resources, skills, and knowledge, reducing excess capacity, developing new capabilities, and accessing new markets through local partners' know-how, technology, and financial resources (Franco et al., 2020; Vatamanescu et al., 2019).

Internationalization is a complex strategic decision requiring significant investment and affecting organizational performance (Vatamanescu et al., 2014-2022; Song et al., 2015). Multinational corporations dominate due to their ambition, leadership, financial capacity, and resources. Knowledge and learning, especially from B2B relationships and networks, are crucial for development (Casillas et al., 2009; Singh et al., 2022). Managers must identify and pursue multiple international opportunities to understand and acquire knowledge related to internationalization (Meyer et al., 2023). Firms now transcend not only physical frontiers but also digital ones, leveraging global e-commerce and digital platforms to market products, services and solutions (Purkayastha et al., 2021). Substantial investment is channelled into digitalisation in anticipation of performance gains, and numerous recent studies have explored how such investment enhances organisational outcomes (Cui et al., 2022).

In the internationalisation process, integrating emergent technologies—artificial intelligence, cloud computing and blockchain among them—can fundamentally transform how organisations manage operations and engage with overseas markets (Sinha and Roy Chowdhury, 2021; Akter et al., 2022). These technologies complement one another, providing a robust framework for innovation, cost reduction and performance enhancement on international terrains (Sahoo et al., 2024; Silenskyte et al., 2024). Digitalisation also constitutes a decisive response to the competitiveness pressures of a highly globalised marketplace (Vatamanescu et al., 2017). Consequently, organisations intent on maintaining competitiveness and internationalising must focus simultaneously on acquiring new knowledge and adopting novel technologies (Bargoni et al., 2024).

Finally, organisational performance emerges as a direct outcome of internationalisation supported by digitalisation and emergent technologies: firms enhance operational efficiency and strengthen competitive positioning by accessing new markets, optimising supply chains

and adapting to diverse global consumer demands. Thus, internationalisation constitutes both a growth opportunity and a critical lever for long-term performance consolidation (Ding et al., 2021).

Building on these perspectives, the empirical studies resorts to semi-structured interviews with eleven senior managers drawn equally from SMEs and large corporations. It seeks to examine how B2B strategic configurations, when mediated by digital tools, translate into competitive strength and, ultimately, superior organisational performance across borders. Thematic analysis uncovers three interlocking mechanisms: (i) dynamic portfolio adaptation, enabling real-time alignment between product attributes and market micro-segments; (ii) data-enabled orchestration of global partnerships that compresses learning cycles and mitigates distance-related risk; and (iii) digitally driven performance monitoring, which transcends conventional financial metrics by integrating customer-centric and sustainability indicators.

## **2. Methodology**

The empirical research is founded on a semi-structured interview design. Semi-structured interviewing is widely recognized in the social sciences as a technique that balances comparability across cases with the flexibility to explore emergent themes—making it an appropriate choice for capturing the nuanced managerial insights underlying internationalisation processes.

The protocol included twelve open-ended questions to gather participants' experiences and perceptions regarding three main constructs: (i) B2B managerial strategies and practices, (ii) competitiveness driven by digitalisation, and (iii) organisational performance. This exploratory approach aims to reveal the relationship among the constructs and establish a basis for the study's subsequent quantitative phase.

Data were collected remotely between January and February 2025 through e-mail exchanges or secure virtual-meeting platforms, in accordance with logistical constraints and the preferences expressed by the interviewees. All conversations were conducted in Romanian, audio-recorded with prior consent, and transcribed verbatim.

The sample included eleven senior Romanian managers who have extensive experience in corporate leadership and cross-border business development (Table 1). They hold pivotal positions in both large corporations and SMEs operating in IT&C, construction, automotive, agribusiness, food production, and financial-banking services. This diverse yet information-rich perspective provides valuable insights into strategy, digital transformation, and performance management.

Rigour was enhanced through constant comparison, investigator triangulation, and active searches for disconfirming evidence. Participants' anonymity was preserved using initials that are not uniquely traceable (e.g., V.P., L.D.). Credibility was reinforced through member-checking, where preliminary interpretations were returned to interviewees for validation and clarification of any ambiguities.

Two limitations should be acknowledged. First, the modest sample size ( $n = 11$ ), although typical of exploratory work, limits statistical generalisation. Second, focusing exclusively on Romanian managers may restrict transferability to other institutional settings; replication in different socio-cultural contexts would enhance external validity.

Despite these limitations, the methodology provides a robust framework to observe the interactions between strategy, digitalisation, and performance as precursors to successful internationalisation, thereby meeting the exploratory objectives of this investigation.

*Table 1: Profile of respondents in the qualitative research*

| No. | Initials | Position                                                         | Industry                       | Educational Level | Company Size  |
|-----|----------|------------------------------------------------------------------|--------------------------------|-------------------|---------------|
| 1.  | V.P.     | Vice President, Board Member, Chief Strategy & Operating Officer | IT & C                         | Higher education  | Large company |
| 2.  | L.D.     | Head of Communications Region                                    | CEE Finance / Banking          | Higher education  | Large company |
| 3.  | D.F.     | General Manager                                                  | Construction Industrial Sector | Higher education  | Large company |
| 4.  | V.S.     | Founder and General Manager                                      | Food Industry                  | Higher education  | SME           |
| 5.  | I.L.     | Founder and General Manager                                      | Automotive                     | Higher education  | SME           |
| 6.  | P.Z.     | Regional HR Director EMEA (Europe, Middle East, and Africa)      | Automotive                     | Higher education  | Large company |
| 7.  | O.B.     | Development Director                                             | IT & C                         | Higher education  | Large company |
| 8.  | R.S.     | Founder and General Manager                                      | Food Industry                  | Higher education  | SME           |
| 9.  | P.M.     | Chief of Marketing                                               | Food Industry                  | Higher education  | Large company |
| 10. | D.C.     | Communications & Public Affairs Coordinator                      | Automotive                     | Higher education  | Large company |
| 11. | D.A.     | Head of Open Market                                              | IT & C                         | Higher education  | Large company |

*Source: own elaboration*

### 3. Results

This section synthesises the findings of the qualitative phase and shows how the insights gained from the eleven Romanian executives inform the conceptual framework that will later be tested quantitatively. It is organised around three themes: (i) B2B managerial strategies and practices for internationalisation, (ii) competitiveness enabled by digitalisation, and (iii) organisational performance. The themes are tightly inter-linked, revealing how technology-mediated managerial intent translates into competitive strength abroad and, ultimately, superior firm outcomes.

Managers discussed strategies to meet market demands, form partnerships, and ensure sustainable growth. The study details how managers define and implement internationalization strategies, adapt them to external market demands, and address associated challenges. The findings explore the role of digital transformation in enhancing international competitiveness. Participants described their experiences with adopting and integrating modern digital tools and explained how these technologies improve operational efficiency, simplify decision-making, and strengthen competitive positioning in global markets. The final section analyzes organizational performance influenced by internationalization efforts, examining key performance indicators (KPIs) such as profitability, market share, and customer satisfaction alongside industry-specific metrics.

#### 3.1. B2B managerial strategies and practices for internationalisation

P.Z. explains that the expansion process typically begins with a strategic decision at the group level, followed by the operational development of a new factory. *‘The first step is to determine the optimal location for the factory based on a complex analysis. Investment evaluation and cost forecasting are conducted, considering the region's economic potential and available human resources, as success relies on access to a skilled workforce. Only after this*

*preliminary stage do we proceed to plan the operational and commercial details'* (P.Z.). This approach highlights a global standardisation strategy.

One practice developed by the companies before making internationalisation decisions is participation in international trade fairs and industry events. Attending events such as Anuga, the world's largest food fair, and SIAL Paris, a central venue for food industry manufacturers and distributors, has facilitated the identification of opportunities and the establishment of strategic relationships (Respondent V.S.). The strategy involves utilising hubs through formal international meetings.

Companies can expedite achieving competitive positions in global markets through strategic actions such as launching innovative products, establishing competitive pricing, and forming direct relationships with local partners to boost visibility. A decisive market entry strategy facilitates results in dynamic sectors with fierce competition (Respondent D.C.). Success requires rapid and assertive action, adapting business models sustainably, and timely partnerships with local entities who drive most sales. To achieve global success, product portfolios must be adapted using differentiation strategies. Integrating new complementary product categories motivates market entry even when it appears saturated (Respondent O.B.). In doing so, the goal is to develop and adapt existing products for international markets by introducing new categories, allowing the company to reach diverse consumers and meet foreign market needs. Put in other words, this approach aligns with resource search strategies in internationalisation.

Two companies in the interview recommend a gradual expansion strategy for entering international markets. This approach allows controlled entry and fast adaptation to local conditions. The project began with initial steps like testing user interaction and identifying requirements, followed by scaling up the product: *'Ensuring compliant and secure services according to each country's regulations was essential'* (L.D.). Following this conceptual pattern, P.M. highlighted that their growth strategy is methodical and systematic, based on deep sector knowledge and recognition of business challenges. This careful planning aims to ensure the company's long-term success and resilience.

These legal entities are established with the explicit intention of operating on an international level, as evidenced by I.L.'s own statements regarding the business he founded: *'From the company's inception, its strategic direction was oriented towards the international market. The majority of our projects are carried out for international clients, providing us with a distinct advantage'*. This standpoint is further substantiated by the testimony of respondent L.D., who asserts that: *'The products are designed on a global scale, with minimal adaptation to local markets. The adaptation of policies to local specifics is more closely associated with customer support and adherence to local legislation or explicit requests from regulatory authorities'*. That is to say, it's being suggested that a standardisation strategy is adopted in the context of internationalisation.

Conversely, when companies lack adequate preparation to confront the challenges of the international market, as is often observed in emerging industries, they must adopt a flexible approach, either by adjusting product offerings or by customising processes, as interview participant D.F. noted.

O.B. states that to enter international markets, the organisation considers local market specifics and allocates resources accordingly. In operationalising it at an organizational level, the designated division handles this responsibility. Each market has unique needs and regulations, so products are adapted to meet local requirements. The company also ensures product development adheres to safety standards, energy efficiency, and compatibility for smooth integration into local ecosystems.

### **3.2. The role of key stakeholders in internationalisation**

Holistically, the main point that emerged is that stakeholder support might be a decisive enabler of successful expansion abroad. That is, Respondent V.P. underlined the gate-keeping influence of regulators, noting that *'each country has its own legal requirements, and we must comply with them before we can operate'*. Equally indispensable, in the early entry stage, are local partners *'because without their collaboration we cannot deliver services until we build our own infrastructure'* (V.P.).

Moreover, strategic alliances with domestic distributors are a favoured route to market. In this respect, Respondent O.B. explained that when the firm wishes to reach consumers more rapidly it *'focuses on strategic partnerships with local distributors'*. The customer, however, remains the ultimate arbiter of internationalisation decisions. As Respondent R.S. put it: *'For us, entrepreneurship entails a constant responsibility towards the client, who must always be at the centre of our concerns. We choose those markets where we can provide a positive consumer experience—this is the essence of any successful business.'*

Marketing agencies and local investors can boost cross-border expansion. Respondent P.M. noted that *'local marketing agencies adjust brand messages and create culture-specific advertising campaigns. Local investors also finance and support new locations'*. What is more, supply-side stakeholders appear to be crucial. Respondent D.C. stated raw-material suppliers are *'the most important stakeholders,'* whereas Respondent D.F. highlighted the essential role of *'logistics-service providers in delivering projects correctly and on time'*.

Beyond this, external expertise is crucial. Respondent L.D. emphasized that consultants must understand market dynamics to create attractive and relevant offerings for customers. Likewise, Respondent V.S. identified other stakeholders like retailers, marketplace representatives, and logistics partners as essential for international success. Additionally, several interviewees highlighted their workforce's importance. Respondent P.Z. stated: *'Our employees drive our international success by implementing our practices and standards globally'*.

Collectively, these testimonies depict internationalisation as a multi-actor undertaking in which regulators, customers, local partners, investors, suppliers, consultants, logistics providers and employees each perform context-specific yet interdependent functions that collectively determine the pace and efficacy of a firm's global expansion.

### **3.3. Market-selection methods**

Interviewee V.S. stressed that target-market selection rests on several determinants, chief among them the demand for a diversified services portfolio and the need to improve service quality. The screening exercise is therefore built on a multifactorial analysis: *'We assessed each market's consumption potential to gauge demand for our products, focusing on economic stability and the regulatory environment. We prioritised predictable business contexts'*. He likewise highlighted competitive scrutiny: *'If a market was already saturated, we looked for ways to differentiate ourselves or for unexploited niches'*.

In parallel, Respondent I.L. outlined a clear, results-oriented approach structured around three core criteria: *'When deciding which markets to enter, we analyse the industry's maturity, the degree of innovation and prevailing price levels in that region'*. Correct alignment between market potential and the firm's internal capabilities can tip the decision to enter, for internal standards and delivery requirements must be upheld if the business model is to remain effective. Accordingly, Respondent P.Z. explained: *'We focus on markets that match our product portfolio and quality requirements, taking into account compliance with ISO 9001 for quality management and ISO 14001 for environmental management. We also assess whether those*

*markets can meet our just-in-time delivery needs so we can respond rapidly and efficiently to clients'.*

Pervasively, companies seeking successful international expansion must weigh key factors such as economic growth prospects, competitive intensity and strategic fit with the organisation's overarching objectives.

### **3.4. Challenges in implementing managerial strategies and practices**

Companies face many challenges when expanding internationally due to rapid technological changes and the need to adapt in a digitally connected global market. One major barrier is financial; expansion requires continuous capital, and launching new products needs significant resources, so firms must find ways to secure external funding.

Broader product portfolios can serve diverse international markets but also add financial strain. Respondent R.S. stated that expanding into new markets requires rapid adaptation and constant investment, and while diversification is beneficial long-term, resource allocation must be balanced to maintain financial sustainability. Interviewees highlighted external shocks like inflation, the war in Ukraine, and rising costs, which have reduced consumer purchasing power, lowered product demand, and hindered companies' ability to invest in new markets.

Equally important, further obstacles arise from the need to comply with each target country's legal requirements, manage economic and currency risks and bridge cultural divides. One respondent explained: *'We have adopted hedging strategies and negotiate contracts in stable currencies. In some countries, building trust takes longer and requires a constant presence'* (V.S.). A similar view came from D.A., who concluded that *'the main challenges in adopting internationalisation strategies include cultural and linguistic barriers, complex regulations and intense competition in foreign markets'*.

Other managers highlighted difficulties in securing specialised human capital and in navigating logistical bottlenecks. D.F. noted that a major impediment is *'finding niche specialists—professionals who already possess or can quickly acquire industry-specific skills. This complicates recruitment and undermines our ability to deliver projects to the required standards, especially in international markets where expectations are very high'*. He added that *'road infrastructure slows the transport of our materials and can delay project kick-off'* (D.F.).

Concurrently, strategic shortcomings within the firm may prove equally constraining. L.D. pointed to *'a lack of talent truly capable of managing large-scale international projects and leaders who remain overly focused on traditional operations in empirically controlled environments, showing little interest in performance management'*. Beyond this, resistance to remote collaboration emerged as another barrier. According to I.L.: *'Many firms are used to working only with local suppliers and hesitate to outsource services to remote teams. To overcome that obstacle, we build strong client relationships and demonstrate through our projects that we deliver high-standard solutions regardless of location'*.

Finally, certain companies encounter risks due to swift technological advancements that may diminish returns or necessitate unanticipated capital expenditures. As V.P. cautioned: *'The markets in which we operate evolve rapidly both in terms of technology and customer behaviour. The risk of obsolescence due to emerging technologies is genuine and may require substantial investment to modernise our infrastructure'*.

Jointly, these statements illustrate a complex landscape encompassing financial, regulatory, human-resource, logistical, cultural, and technological challenges—each requiring meticulous management for firms to convert strategic intent into sustained success in the international arena.

### **3.5. Digitization and competitiveness through internationalization**

The strategic deployment of digital technology allows firms to communicate more fluidly with prospective customers, track their behavioural patterns and anticipate market trends. Even more importantly, these technologies enable companies to design and simulate bespoke solutions while monitoring international markets in real time. Subsequently, organisations can approach clients with tailored, data-grounded proposals. As Respondent D.F. put it: *'Digital tools, first and foremost, help us identify potential customers and make initial contact. They then support us in planning and simulating solutions, and they let us track global market movements in real time so we can foresee emerging trends'*.

To widen their reach, pinpoint qualified prospects and consolidate their international presence, several firms pair artificial-intelligence analytics with professional social media. Respondent I.L. explained: *'We use AI to optimise both our marketing messages and SEO strategy, and LinkedIn is the main channel through which we promote our services and generate leads'*. Smart digital solutions—enterprise-resource-planning suites and business-analytics platforms in particular—facilitate efficient inventory and sourcing management, allow rapid reallocation of investment and confer an edge over rivals that still rely on traditional decision cycles. Respondent O.B. observed: *'The platforms we employ let us manage stocks and procurement more efficiently, cut costs and plan long term, especially given the current supply-chain disruptions. Because we can anticipate local demand and keep prices competitive, we enjoy a strategic advantage when expanding and adapting abroad'*.

In parallel, advanced technologies such as artificial intelligence (AI), process automation and cloud services have radically altered the way companies engage with global markets by enhancing operational efficiency and enabling swift responses to market shifts. Respondent V.S. confirmed: *'We used AI to analyse markets and identify consumption trends, which helped us make better-informed strategic decisions'*. Cloud computing, in particular, gives new entrants the agility and remote operability they need before a full in-country infrastructure is in place—a reality reflected in Respondent V.P.'s experience: *'Cutting-edge technologies, cloud solutions included, not only support our international expansion by ensuring high-quality connectivity; they also form an important part of our own offer, because we provide such services to our corporate clients'*.

Supplementary, e-learning platforms have become a valuable resource for improving employee and partner performance regardless of location, especially during expansion into emerging markets. Two of the organisations studied confirmed the practice. Respondent P.Z. noted: *'We need a development and training programme for our people, and it is fully digitalised.'* Similarly, in the Romanian café chain analysed, digitalisation yielded a portal for *'enhancing staff and partner performance, plus an app—available in every country we operate in—that tells clients where the nearest outlet is and details the products on sale'* (R.S.).

The Internet of Things (IoT) and AI are transforming global operations, accelerating processes, enriching the customer experience and lifting overall performance. Respondent D.C. highlighted investments in IoT-enabled connected vehicles: *'These include advanced infotainment systems, roadside-assistance services and other features that turn the car into a connected device'*. AI also plays a central part, as Respondent D.C. added, citing autonomous-vehicle development through partnerships such as the one with Argo AI.

In today's hyper-globalised economy, blockchain ranks among the most effective technologies for handling international financial transfers. Its decentralised, secure architecture allows fast, transparent cross-border transactions. L.D. argued that using cryptocurrency *'dramatically cuts the cost of processing international payments by eliminating intermediaries,*

*letting us offer more affordable services to our clients. In addition, cryptocurrencies open doors to emerging markets where conventional banking is limited or absent’.*

E-commerce platforms likewise accelerate foreign-market entry and underpin rapid scaling. Respondent R.S. recounted: *‘One of our main objectives was to expand into e-commerce so consumers could access our products 24 / 7. We found it far more efficient to list on established platforms; they have become our most effective technological tools, giving us a quick, low-cost route into new markets, improving brand visibility and allowing us to meet consumer demand more flexibly’.* Operational efficiency underpins international success, and V.S. identified three digital dividends: (i) greater efficiency through *‘process automation, which has reduced human error and order-processing time’*; (ii) faster expansion because *‘digitalisation lets us scale without a physical presence in every country’*; and (iii) lower costs because *‘digital solutions have cut administrative and logistics expenditure.’*

It has become clear that digital adoption has become a catalyst for organisational transformation, reshaping operational dynamics and the way firms interact with international markets. The resulting agility enables them to anticipate trends and adapt proactively to global customer requirements, thereby reinforcing competitive positioning in a dynamic, highly interconnected environment. Nonetheless, integrating digital technologies abroad is complex and rife with challenges. Respondent I.L. cited three major impediments: *‘management’s resistance to unfamiliar software; inadequate budgets for new digital solutions; and excessively cumbersome processes, particularly when we work with very large companies’.*

As well as that, cyber-security threats remain ever-present. Respondent L.D. reported that attacks are a *‘constant challenge’*, to which the company has responded by *‘continually enhancing security features in its applications to protect customers from potential fraud’.* Finally, digitalisation can trigger significant cultural friction. As Respondent P.Z. explained: *‘As an international company operating in several countries—each with different cultures, visions and capabilities—we faced multiple hurdles in standardising operations. Digitalisation turned out to be especially difficult from a cultural standpoint’.*

Overall, the evidence underscores that thoughtfully deployed digital technologies are integral to building and sustaining competitiveness during international expansion, even as firms navigate the financial, managerial and cultural headwinds that accompany such transformative change.

### **3.6. Organizational Performance**

A primary benefit lies in risk dispersion: entering additional markets reduces dependence on the domestic arena and cushions exogenous shocks. Respondent V.S. reported that overseas entry *‘reduced our reliance on the local market and gave us greater financial stability’.* In the same vein, Respondent O.B. observed that geographical diversification *‘has markedly increased the contribution of foreign markets to total turnover ... while dampening the risks linked to economic fluctuations in particular regions’.* In the same fashion, Respondent L.D. noted a sharp rise in scale and reach: *‘We now operate in 38 markets worldwide and serve more than 50 million retail clients’.*

Furthermore, it is important to put forth that internationalisation also amplifies brand recognition. According to Respondent V.S., a foreign presence *‘has reinforced our image as a premium brand’*, attracting new customers and deepening trust. Respondent R.S. added that global expansion *‘presented a unique opportunity to popularise our brand and to build a worldwide community of coffee lovers’.*

On top of this, exposure to diverse market requirements stimulates innovation and thus consolidates competitive advantage abroad. In line with this, Respondent V.S. reflected that

*‘we have had to innovate continuously to remain relevant internationally’. Additionally, Respondent D.F. confirmed: ‘Expansion has diversified our revenue streams and bolstered organisational resilience—it allowed us to optimise internal processes and become more competitive across every market in which we operate’. P.Z. likewise recorded ‘a considerable improvement in operational efficiency; our products now enjoy greater appreciation on a global scale’.*

Another noteworthy point is that operational efficiency and robust partnerships are further dividends of going global. Respondent O.B. emphasised *‘stronger relations with strategic partners’* as a driver of process gains. In agribusiness, P.M. observed that international reach *‘has improved access to digital solutions and tailored finance, accelerating the adoption of technologies that maximise yields and profitability’.*

Contrary to fears of crowding out, overseas success often feeds back into the home base. Respondent V.P. explained that strategic acquisitions and foreign growth *‘have underpinned sustainable expansion at home’*, financing product development and infrastructure upgrades without harming the local market. Performance improvements materialise visibly in key metrics. That is, *‘significant increases in market share, sales volume and customer satisfaction’*, recorded D.A., confirming therefore the effectiveness of the chosen strategies.

Measurement, however, must be industry-specific. In automotive, Respondent I.L. tracks *‘revenue growth from foreign markets, projects won and international lead-conversion rates’*. What is more, Respondent V.S. focuses on *‘overseas revenue and its share of total income,’* complemented by analyses of *‘profit margins and region-specific cost structures’*. Beyond this, D.F. relies on *‘return on investment to judge whether spending on infrastructure, technology and product adaptation is delivering the expected returns’*. Changing the viewpoint, Respondent V.P. looks at *‘number of markets served, market share by service category, revenue-generating units and total turnover’*, while Respondent O.B. monitors *‘the share of exports in total revenue and the penetration rate in new markets’*. In his sector, Respondent D.C. tracks *‘turnover, external-market revenue and units sold per model, which helps us understand customer preferences’*.

All in all, respondents reported marked improvements in these indicators after internationalisation. Yet vigilance remains essential: should performance stall or decline, some firms opt for withdrawal or divestment. As Respondent V.P. explained, *‘When results fall short of expectations, we reassess our market strategy—closure of operations is one option on the table’*. Convergently, the evidence shows that the interplay of well-crafted strategies, efficient operations and sustained competitiveness makes internationalisation a decisive lever for long-term organisational success.

## **4. Discussion**

As we have tried to put forth, businesses intent on expanding abroad must devise strategies attuned to the cultural, economic and legal specificities of each target market. The literature confirms that flexible, adaptive approaches enable organisations to address local requirements efficiently and to recalibrate their strategy as learning unfolds (Pahrizal et al., 2024; Vatamanescu et al., 2020a). Putting theory into practice, the interviewees favour a gradual pattern of internationalisation, built around strategic partnerships, which they regard as indispensable for achieving both financial and operational performance. Conceptually, this finding aligns with the work of Vatamanescu et al. (2014, 2015, 2016b, 2017, 2020b), who highlight the value of adaptive, stepwise expansion and the pivotal role of relational capital in forging the alliances that underpin international growth.

International expansion nonetheless confronts firms with a complex mix of challenges. Internal pressures—such as the need for continuous innovation and for up-skilling human resources—intersect with external constraints, including macro-economic volatility, cultural distance and rigid or inefficient regulation. The respondents underscored the importance of stable, supportive regulatory frameworks, echoing Chandra et al. (2021), who warn that an unfavourable institutional environment can stifle even managerially competent, entrepreneurially oriented firms seeking to enter new markets.

All interviewees acknowledged the decisive contribution of digital technologies to successful expansion. Advanced solutions—artificial intelligence, cloud computing and business-analytics platforms—confer a competitive advantage (Fraccastoro et al., 2025; Vatamanescu, 2017) by streamlining operations, informing strategic choices and enabling fast responses to market shifts. This empirical insight mirrors the conceptual argument advanced by Lee et al. (2019), namely that digitalisation accelerates internationalisation and affords firms a differentiated strategic position.

As we have empirically witnessed, organisational performance is strongly conditioned by the internationalisation journey itself. Diversified revenue streams, higher competitiveness and superior operational efficiency emerge once firms adapt to external market requirements and implement well-defined strategies. Business networks play a crucial part in this process (Vatamanescu et al., 2018a; 2018b), facilitating knowledge transfer from seasoned managers to less-experienced leaders and thereby fostering resilient collaboration and enhanced organisational outcomes (Vatamanescu et al., 2020b, 2022a, 2022b).

## **5. Conclusions**

Broadly, the qualitative analysis offers an in-depth view of how B2B managerial strategies and practices, together with international digitalisation efforts, shape competitiveness and organisational performance. By tailoring their approach to foreign-market demands and deploying carefully crafted strategies, the firms studied demonstrated tangible pay-offs from internationalisation: revenue diversification, heightened competitiveness and sharper operational efficiency. The data portray a holistic conception of performance that blends financial and operational indicators with a long-term strategic perspective.

Engagement in cross-border activity strengthens not only global positioning but also organisational learning. Informal business networks facilitate the exchange of knowledge between experienced managers and emerging leaders, thereby supporting sustainable collaboration and the design of effective expansion strategies. Theoretically, our findings reinforce the premise that digitalisation, competitiveness through internationalisation and judiciously selected B2B managerial practices constitute a central pillar of international success, and they lay the groundwork for the forthcoming quantitative study.

Several limitations warrant acknowledgment. First, the interview pool—eleven participants—necessarily constrains the generalisability of the results. Second, the inclusion of only one representative per sector and the exclusive focus on Romanian managers circumscribe the applicability of the conclusions to other cultural and economic settings. Third, the varied firm sizes represented may yield heterogeneous perspectives that limit interpretive consistency. Future research could enrich the qualitative strand by engaging a larger cohort drawn from a single industry or organisational type (SME or large corporation), thereby offering a more finely contextualised picture of internationalisation's impact.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions of privacy and ethical

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Akter, S., Michael, K., Uddin, M. R., et al. (2022). Transforming business using digital innovations: The application of AI, blockchain, cloud and data analytics. *Annals of Operations Research*, 308(1-2), 7-39. <https://doi.org/10.1007/s10479-020-03620-w>
- Anggara, A. A., Aryoko, Y. P., Dewandaru, R. O., Kharismasyah, A. Y., & Fatchan, I. N. (2025). Does maintaining resources, diversification, and internationalization matter for achieving high firm performance? A sustainable competitiveness strategy for China Taipei firms. *Sustainability*, 17(4), 1576. <https://doi.org/10.3390/su17041576>
- Arbelo, A., Arbelo-Perez, M., & Perez-Gomez, P. (2024). Internationalization and individual firm performance: A resource-based view. *Eurasian Business Review*, 14(4), 881–915. <https://doi.org/10.1007/s40821-024-00276-5>
- Bargoni, A., Ferraris, A., Vilamova, S., & Wan Hussain, W.M.H. (2024). Digitalisation and internationalisation in SMEs: a systematic review and research agenda. *Journal of Enterprise Information Management*, 37(5), 1418-1457. <https://0z10yfhaq-y-https-doi-org.z.e-nformation.ro/10.1108/JEIM-12-2022-0473>
- Bi, S., Sass, M., & Gáspár, T. (2024). Internationalization strategy management for small and medium-size enterprises: A case study of LED industrial enterprise. *Corporate & Business Strategy Review*, 5(1), 204–215. <https://doi.org/10.22495/cbsrv5i1art19>
- Casillas, J. C., Moreno, A. M., Acedo, F. J., Gallego, M. A., & Ramos, E. (2009). An integrative model of the role of knowledge in the internationalization process. *Journal of World Business*, 44(3), 311-322. <https://doi.org/10.1016/j.jwb.2008.08.001>
- Cui, Y., Liu, L., & Peng, K. (2022). International competitiveness and currency internationalization: An application to RMB internationalization. *Journal of the Asia Pacific Economy*, 29(2), 588–611. <https://doi.org/10.1080/13547860.2022.2031521>
- Ding, S., McDonald, F., & Wei, Y. (2021). Is internationalization beneficial to innovation? Evidence from a meta-analysis. *Management International Review*, 61(3), 469–519. <https://doi.org/10.1007/s11575-021-00451-0>
- Du, J., Zhu, S., & Li, W.H. (2023). Innovation through internationalization: A systematic review and research agenda. *Asia Pacific Journal of Management*, 40(3), 1217–1251. <https://doi.org/10.1007/s10490-022-09814-z>
- Efrat, K., Gilboa, S., & Yonatany, M. (2017). When marketing and innovation interact: The case of born-global firms. *International Business Review*, 26(2), 380-390. <https://doi.org/10.1016/j.ibusrev.2016.09.006>
- Fraccastoro, S., Vanninen, H., & Gabrielsson, M. (2025). Two decades of research on digitalization, entrepreneurship, and internationalization: What foundations do they provide for research on digital entrepreneurial internationalization? *International Business Review*, 2025, 102455. <https://doi.org/10.1016/j.ibusrev.2025.102455>
- Franco, M., Haase, H., & Rodini, A. (2020). The role of incubators in the internationalization process of incubated SMEs: A perspective of international cooperation. *Global Business Review*, 24(3), 488–509. <https://doi.org/10.1177/0972150920919381>
- Cha, H., Kotabe, M., & Wu, J. (2023). Reshaping internationalization strategy and control for global e-commerce and digital transactions: A Hayekian perspective. *Management International Review*, 63(1), 161–192. <https://doi.org/10.1007/s11575-022-00494-x>
- Chandra, A. A., Paul, J., & Chavan, M. (2021). Internationalization challenges for SMEs: Evidence and theoretical extension. *European Business Review*, 33(2), 316–344. <https://doi.org/10.1108/EBR-08-2019-0164>
- Kessler, A., & Zipper-Weber, V. (2023). Born-again global internationalization in family businesses as a process: A dynamic capabilities perspective in the context of socioemotional wealth. *Journal of Family Business Management*, 13(4), 1366–1391. <https://doi.org/10.1108/JFBM-01-2023-0005>
- Lee, Y.-Y., Falahat, M., & Sia, B.-K. (2019). Impact of digitalization on the speed of internationalization. *International Business Research*, 12(4), 1-12. <https://doi.org/10.5539/ibr.v12n4p1>

- Meyer, K. E., Li, J., Brouthers, K. D., & Jean, R. (2023). International business in the digital age: Global strategies in a world of national institutions. *Journal of International Business Studies*, 54(4), 577-598. <https://doi.org/10.1057/s41267-023-00618-x>
- Pahrizal, P., Sudarmiatin, S., & Sumarsono, H. (2024). Business internationalization strategy process review based on the Uppsala model. *GRM Advances in Business and Management*, 4(2). <https://doi.org/10.52970/grmapb.v4i2.285>
- Purkayastha, A., Kumar, V., & Gupta, V. K. (2021). Emerging market internationalizing firms: Learning through internationalization to achieve entrepreneurial orientation. *Journal of World Business*, 56(5), 10120. <https://doi.org/10.1016/j.jwb.2021.10120>
- Sahoo, S., Kumar, S., Mukherjee, D., & et al. (2024). Internationalization via industry 4.0 technologies: Application areas and future roadmap for international business. *Management Review Quarterly*. <https://doi.org/10.1007/s11301-024-00459-4>
- Silenskyte, A., Butkeviciene, J., & Bartminas, A. (2024). Blockchain-based connectivity within digital platforms and ecosystems in international business. *Journal of International Management*, 30(3), 101109. <https://doi.org/10.1016/j.intman.2023.101109>
- Singh, R., Chandrashekar, D., Mungila Hillemane, B. S., Sukumar, A., & Jafari-Sadeghi, V. (2022). Network cooperation and economic performance of SMEs: Direct and mediating impacts of innovation and internationalisation. *Journal of Business Research*, 148, 116-130. <https://doi.org/10.1016/j.jbusres.2022.04.032>
- Sinha, D., & Roy Chowdhury, S. (2021). Blockchain-based smart contract for international business – a framework. *Journal of Global Operations and Strategic Sourcing*, 14(1), 224-260. <https://doi.org/10.1108/JGOSS-06-2020-0031>
- Song, S., Makhija, M., & Kim, S. M. (2015). International investment decisions under uncertainty: Contributions of real options theory and future directions. *Journal of Management & Organization*, 21(6), 786–811. <https://doi.org/10.1017/jmo.2014.90>
- Vatamanescu E.-M., Alexandru, V.-A., & Andrei A.G. (2015). The relational leader. A preliminary framework for corporate intercultural accommodation. In: *3rd Strategica. Local versus Global* (pp. 303-312). Tritonic.
- Vatamanescu E.-M., Zbucnea, A., Pinzaru, F., & Andrei, A.G. (2016b). The Impact of Relational Capital on SME Internationalization. Leveraging Online Versus Offline Business Networking. In: *17th European Conference on Knowledge Management* (pp. 926-935). Academic Conferences and Publishing International Limited.
- Vatamanescu, E.-M., Alexandru, V.-A., & Gorgos, E.-A. (2014). The Five Cs Model of Business Internationalization (CMBI) – a preliminary theoretical insight into today's business internationalization challenges. In: *2nd Strategica. Management, Finance, and Ethics* (pp. 537-558). Tritonic.
- Vatamanescu, E.-M., Alexandru, V.-A., Cristea, G., Radu, L., & Chirica, O. (2018a). A Demand-Side Perspective of Bioeconomy: The Influence of Online Intellectual Capital on Consumption. *Amfiteatru Economic*, 20(49), 536-552.
- Vatamanescu, E.-M., Alexandru, V.-A., Mitan, A., & Dabija, D.-C. (2020b). From the deliberate managerial strategy towards international business performance: A psychic distance vs. global mindset approach. *Systems Research and Behavioral Science*, 37(2), 374-387. <https://doi.org/10.1002/sres.2658>
- Vatamanescu, E.-M., Andrei, A.G., & Pinzaru, F. (2018b). Investigating the online social network development through the Five Cs Model of Similarity: the Facebook case. *Information Technology & People*, 31(1), 84-110. <https://doi.org/10.1108/ITP-06-2016-0135>
- Vatamanescu, E.-M., Bratianu, C., Dabija, D.-C., & Popa, S. (2023). Capitalizing online knowledge networks: From individual knowledge acquisition towards organizational achievements. *Journal of Knowledge Management*, 27(5), 1366–1389. <https://doi.org/10.1108/JKM-04-2022-0273>
- Vatamanescu, E.-M., Cegarra-Navarro, J.-G., Martinez-Martinez, A., Dinca, V.-M., & Dabija, D.-C. (2022c). Revisiting online academic networks within the COVID-19 pandemic – From the intellectual capital of knowledge networks towards institutional knowledge capitalization. *Journal of Intellectual Capital*, 24(4), 948-973 <https://doi.org/10.1108/JIC-01-2022-0027>
- Vatamanescu, E.-M., Gorgos, E.-A., Ghigiu, A.M., & Patrut, M. (2019). Bridging Intellectual Capital and SMEs Internationalization through the Lens of Sustainable Competitive Advantage: A Systematic Literature Review. *Sustainability*, 11(9), 2510. <https://doi.org/10.3390/su11092510>
- Vatamanescu, E.-M., Mitan, A., Andrei, A.G., & Ghigiu, A.M. (2022a). Linking coopetition benefits and innovative performance within small and medium-sized enterprises networks: a strategic approach on knowledge sharing and direct collaboration. *Kybernetes*, 51(7), 2193-2214. <https://doi.org/10.1108/K-11-2020-0731>

*From Strategy and Practice to Success in Internationalization:  
A Qualitative Approach  
Elena Adriana Biea, Victor Ciuciuc*

- Vatamanescu, E.-M., Mitan, A., Cotirlet, P.C., & Andrei, A.G. (2022b). Exploring the Mediating Role of Knowledge Sharing between Informal Business Networks and Organizational Performance: An Insight into SMEs Internationalization in CEE. *Sustainability*, 14(7), 3915. <https://doi.org/10.3390/su14073915>
- Vatamanescu, E.-M., Pinzaru, F., Andrei, A.G., & Zbucnea, A. (2016a). Investigating SMEs sustainability with partial least squares structural equation modeling. *Transformations in Business & Economics (TIBE)*, 15(3), 259-273. <http://www.transformations.knf.vu.lt/39/article/inve>
- Vatamanescu, E.-M., Andrei, A.G., Nicolescu, L., Pinzaru, F., & Zbucnea, A. (2017). The Influence of Competitiveness on SMEs Internationalization Effectiveness. Online Versus Offline Business Networking. *Information Systems Management*, 34(3), 205-219. <https://doi.org/10.1080/10580530.2017.1329997>
- Vatamanescu, E.-M., Cegarra-Navarro, J-G., Andrei, A.G., Dinca, V-M., & Alexandru, V-A. (2020a). SMEs Strategic Networks and Innovative Performance: A Relational Design and Methodology for Knowledge Sharing. *Journal of Knowledge Management*, 24(6), 1369-1392.

## THE NEGATIVE ASPECTS OF ESG IMPLEMENTATION IN SME BUSINESS PRACTICE

Alexandra Hotkova<sup>1,a</sup> and Jaroslav Belas<sup>1,b,\*</sup>

<sup>1</sup>Alexander Dubcek University in Trencin, Faculty of Social and Economic Relations, Studentska 3,  
911 50 Trencin, Slovakia

<sup>a</sup>alexandra.hotkova@tnuni.sk, <sup>b</sup>jaroslav.belas@tnuni.sk

\*Corresponding author

**Cite as:** Hotkova, A., Belas, J. (2025). *The negative aspects of ESG implementation in SME business practise. Ekonomicko-manazerske spektrum*, 19(1), 69-82.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.69-82](https://dx.doi.org/10.26552/ems.2025.1.69-82)

---

*Received: 25 January 2025; Received in revised form: 13 April 2025; Accepted: 25 May 2025; Available online: 30 June 2025*

### Abstract:

**Research background:** The implementation of ESG (Environmental, Social, and Governance) principles has become an integral part of the strategic management of small and medium-sized enterprises (SMEs) in their pursuit of sustainable development. However, their practical application is often accompanied by various negative phenomena.

**Purpose of the article:** This article analyses the barriers and negative attitudes toward ESG implementation in SMEs in the Visegrad Group countries (Slovakia, Czech Republic, Poland, Hungary), with particular attention to the differences between the attitudes of business owners and managers.

**Methods:** The empirical part of the research was conducted through a quantitative questionnaire survey involving 1,549 respondents from SMEs in the V4 countries, with data analysis performed using the chi-square test and Z-score at a significance level of 0.05.

**Findings & Value added:** The results confirm the existence of statistically significant differences between the countries in the degree of negative perception of ESG, particularly in the areas of perceived bureaucratic burden, environmental measures, social aspects, and long-term sustainability. Conversely, differences between owners and managers were found to be predominantly statistically insignificant. The article identifies key implementation barriers, including insufficient strategic anchoring of ESG, low levels of awareness, economic challenges, and organizational resistance to change, while highlighting the need for systematic education and internal capacity building in ESG.

**Keywords:** ESG; barriers; negative perceptions; stakeholder resistance

**JEL Classification:** M14; L26; Q56

## 1. Introduction

The integration of environmental, social, and governance (ESG) principles into the business processes of small and medium-sized enterprises (SMEs) represents a significant challenge that can adversely affect their financial stability and competitiveness. Although ESG standards are increasingly perceived as a key component of responsible and sustainable business, their practical implementation often imposes a disproportionate burden in terms of financial costs,

administrative complexity, and external reporting requirements. At the same time, growing societal and institutional pressure for transparency and disclosure of ESG activities compels businesses to align their operations with the expectations of the public and stakeholders.

As noted by Zhang and Cheng (2020), information about a firm's ESG activities significantly influences public perception and can shape attitudes toward the legitimacy of the business. According to Burke (2022), negative publicity regarding ESG performance can trigger heightened societal scrutiny, often prompting firms to take steps to restore their damaged reputation. While such pressures may lead to positive changes, such as increased transparency or the abandonment of undesirable practices (Chen et al., 2020), for SMEs, they can also result in excessive organizational and financial burdens, creating opportunities for superficial or formal adoption of ESG measures.

Although ESG initiatives promote sustainability and enhance stakeholder trust, small and medium-sized enterprises (SMEs) face barriers such as high financial costs, insufficient expertise, and increased administrative burdens, which limit their ability to effectively implement these principles (Setyaningsih et al., 2024; Liou et al., 2023). Low awareness of ESG objectives and limited knowledge of environmental regulations further complicate their efforts to adopt sustainable practices (Abu Hassan et al., 2023). These factors can lead to a decline in financial performance indicators, such as return on equity (ROE) and return on assets (ROA) and divert resources from core business activities (Garrido-Ruso et al., 2024). Moreover, inconsistent regulatory frameworks and inadequate institutional support increase the risk of operational inefficiencies and market exclusion for SMEs (Rizos et al., 2016; Durrani et al., 2024).

This article examines the negative aspects of ESG implementation in SMEs, focusing on financial, organizational, and regulatory barriers. Specifically, it analyzes the negative aspects of implementing environmental, social, and governance (ESG) principles in SMEs within the Visegrad Group (V4) countries. The primary objective is to investigate the attitudes of business owners and managers toward negative perceptions of ESG and to explore differences based on their roles within the company. The uniqueness of the research lies in its scope and comparative perspective, encompassing four V4 countries and revealing statistically significant cross-country differences in approaches to ESG. The study was conducted in May 2025 through an online questionnaire survey, with a total sample of 1,549 respondents. Respondents' attitudes were assessed using a standardized questionnaire based on a five-point Likert scale. To test the formulated hypotheses, statistical methods, including the chi-square test and Z-score, were applied. The article is structured into a theoretical section summarizing insights on ESG in the context of SMEs, a methodological section describing the research design and respondent characteristics, and an analytical section presenting the research findings for each country. The conclusion discusses the identified barriers and proposes recommendations for improving ESG implementation processes in SME business practices.

## **2. Literature review**

The implementation of environmental, social, and governance (ESG) principles in small and medium-sized enterprises (SMEs) is currently regarded as a critical component of sustainable business practices (Shalhoob and Hussainey, 2023). Despite positive expectations, a growing body of literature highlights the barriers and negative aspects associated with ESG adoption, with a particular focus on differences in attitudes between owners and managers (Hrnjica et al., 2024).

A fundamental issue frequently noted in the literature is the lack of managerial support and a strategic framework for ESG. According to Sindhvani et al. (2022), SMEs often lack a long-term ESG strategy, leading to a formal or even symbolic approach where ESG activities are merely declared in internal documents rather than integrated into actual processes. This lack of strategic anchoring manifests in unclear divisions of responsibilities, the absence of internal objectives, and insufficient resource allocation for ESG projects. Low levels of managerial engagement further complicate the alignment of ESG initiatives with corporate culture. As noted by Liou et al. (2023), the internal integration of ESG into decision-making processes often results in a fragmented approach, where ESG measures are implemented without connection to key business metrics. Similar findings were reported by Liu et al. (2022) in their study on the impact of managerial support on ESG adoption in Latin American SMEs. The research revealed that, in the absence of systematic engagement from top management, ESG is perceived as an "additional administrative burden" rather than a competitive advantage, leading to minimal implementation and the rapid decline of initial efforts (Liu et al., 2022). The authors emphasize that for effective ESG integration into strategic planning, SME leadership must define clear objectives, measurable indicators, and accountability mechanisms while providing managers with relevant training and resources.

Another significant negative aspect is the reluctance of businesses to embrace change, often reinforced by the conservative attitudes of owners and fears of failure. Huang et al. (2022) and Ullah et al. (2021) highlight that resistance to innovation is a common barrier to ESG implementation. This attitude is intertwined with low levels of awareness and a tendency to view ESG as external pressure rather than a competitive advantage (Camelo and Nogueira, 2024).

According to Ganc and Felczak (2025), there is a significant knowledge deficit regarding ESG frameworks in small and medium-sized enterprises (SMEs), which complicates their proper implementation. Managers often lack understanding of the differences between various ESG standards, are unfamiliar with measurement methodologies, and struggle to evaluate the impact of specific initiatives on key performance indicators. This knowledge gap leads to the selection of ESG measures that are either excessively costly or insufficient to achieve meaningful environmental or social objectives. Furthermore, research indicates that a substantial proportion of SMEs rely solely on external consulting services, which increases costs and creates dependency on external experts (Ganc and Felczak, 2025; Rumyantseva and Tarutko, 2022). Hussaini et al. (2023) emphasize the importance of interactive educational platforms and mentoring programs to bridge the gap in managerial training for SMEs. In practice, this implies that SMEs should invest not only in external consultations but also in building internal capabilities through workshops, e-learning, or partnerships with academic institutions. Only through such measures can ESG transition from a purely formal process to an integral part of daily decision-making.

The economic aspect of ESG implementation represents another critical challenge. Jamaludin et al. (2025) note that the high initial costs of adopting ESG initiatives are the most significant barrier for small businesses. The low return on these investments, particularly in the short term, discourages managers from pursuing them (Cai et al., 2024). An even more complex issue is the implementation of compensatory mechanisms, such as carbon credits, which may negatively impact local economies without delivering tangible environmental benefits (Agbulut et al., 2020).

In addition to insufficient managerial support, the economic demands associated with initial investments in ESG activities pose a significant obstacle. The implementation of ESG can also have adverse effects on employees. Han and Lee (2024) introduced the concept of ESG stress—

a psychological burden stemming from the uncertainty and complexity of ESG requirements. Similarly, Piao et al. (2022) highlight that pressure for rapid ESG transformation without adequate support can lead to stress, reduced job satisfaction, and employee turnover. This phenomenon also impacts workforce turnover, as noted by Garsaa and Paulet (2023), who demonstrated that poorly managed ESG programs can result in higher employee attrition rates.

The differences in attitudes toward ESG (environmental, social, and governance) initiatives between owners and managers significantly influence decision-making processes within organizations. These differences are particularly evident in the understanding and approach to ESG, where owners and managers often adopt distinct perspectives, impacting the implementation of ESG strategies. Owners typically focus on short-term financial gains and costs, which shapes their view of ESG (Sindhvani et al., 2022). For them, achieving rapid returns on investment and minimizing the costs associated with ESG practices are often priorities. Consequently, they may perceive ESG implementation as a costly and time-consuming process that reduces short-term profitability (Ganc and Felczak, 2025; Belas et al., 2024). In contrast, managers frequently view ESG as an integral part of strategic planning and the long-term development of the organization (Tumwebaze et al., 2022). For managers, ESG is often embedded in their strategic vision, encompassing long-term investments in sustainability and value creation that will benefit the company over time. These managers recognize that ESG can strengthen corporate culture, employee productivity, and customer trust, thereby ensuring sustainable growth and stability (Belas et al., 2024).

Differences in attitudes between owners and managers also manifest in the area of remuneration (Li and Chen, 2024; Khurram et al., 2024). According to research by Meng et al. (2024), ESG initiatives in their early stages may exacerbate disparities in compensation between management and employees, which can negatively affect employee trust and collaboration within the organization. Conversely, owners may support such compensation disparities if they prioritize short-term financial performance and view managerial remuneration as a direct means to incentivize increased profitability.

A significant insight was provided by Acheampong et al. (2025), who revealed that most ESG research focuses on large corporations in developed countries, while SMEs—particularly in developing regions—are minimally covered by research. This gap hinders the transfer of scientific knowledge into the practical environment of small businesses and reduces the applicability of ESG recommendations for this target group.

In summary, the negative aspects of ESG implementation in SMEs are multifaceted, encompassing a lack of support, resources, and strategic planning, as well as psychological and economic barriers. For successful integration of ESG into business practices, it is essential not only to enhance awareness but also to create a supportive environment that accounts for the differing needs and perspectives of owners and managers. The differences in understanding and implementing ESG practices between owners and managers are critical to the development and success of these initiatives within organizations. While owners are often driven by short-term financial goals, managers recognize the importance of ESG for long-term value and stability. These differences can significantly impact remuneration, internal relationships, and the overall design of ESG strategies, necessitating a balance between these perspectives to achieve long-term sustainability and competitiveness.

### **3. Methodology**

Differences in the attitudes of owners and managers toward ESG (environmental, social, and governance) initiatives are pronounced and significantly influence decision-making processes

within organizations. These differences often arise from divergent goals and priorities, which may not align between owners and managers. The successful implementation of ESG in businesses also depends on the collaboration between superiors and management, making it essential to examine potential differences. This study focuses on analyzing the attitudes of owners and managers in businesses with respect to ESG.

The primary objective of the study is to investigate the attitudes of owners and managers toward negative perceptions of ESG and to explore differences based on their roles within the organization.

The empirical research was designed to examine the attitudes of owners and managers toward ESG in the Slovak Republic (SR), the Czech Republic (CZ), Poland (PL), and Hungary (HU). The research was conducted in May 2025. A language-specific version of the questionnaire was developed for each country. Data collection was carried out using Google Forms in collaboration with businesses operating in these countries. The target group consisted of business owners and employees. Several basic questions were used to identify classifying characteristics, including those reflecting the size of the business, its legal form, the sector of operation, the duration of business activity, the gender of respondents, and their position (owner/manager) within the organization. Questions aimed at identifying attitudes related to ESG were defined using a five-point response scale (strongly agree, agree, neutral, disagree, strongly disagree). The number of respondents across the countries included in this study was as follows: (i) Slovakia (n=384); (ii) Czech Republic (n=389); (iii) Poland (n=391); (iv) Hungary (n=385).

Within the scope of this study, the attitudes of business owners and managers toward the following statements were examined:

ST1: *I consider ESG to be bureaucratic nonsense that hinders our business operations.*

ST2: *I view environmental care as excessive and negatively impacting on our business.*

ST3: *Relationships with the community are not important to us; surviving in the market is our priority.*

ST4: *Long-term sustainability of the company is not a key concern for us; our focus is on surviving in the market at present.*

The study formulated several hypotheses:

H1: *There are statistically significant differences in the overall structure of respondents' answers regarding ESG and its reporting.*

H1a: *There are statistically significant differences in the negative attitudes of managers and business owners toward ESG and its reporting.*

H2: *There are statistically significant differences in the overall structure of respondents' answers regarding environmental care.*

H2a: *There are statistically significant differences in the negative attitudes of managers and business owners toward environmental care.*

H3: *There are statistically significant differences in the overall structure of respondents' answers regarding relationships with the community.*

H3a: *There are statistically significant differences in the negative attitudes of managers and business owners toward relationships with the community.*

H4: *There are statistically significant differences in the overall structure of respondents' answers regarding the long-term sustainability of the business.*

H4a: *There are statistically significant differences in the negative attitudes of managers and business owners toward the long-term sustainability of the business.*

To test the formulated hypotheses, the chi-square test and Z-score statistical methods were employed, both applied at a significance level of p-value 0.05. The chi-square test is used to

assess the relationship between two or more variables, determining whether they are dependent or independent. In the context of this study, it was applied to analyze the overall structure of respondents' answers.

The Z-score was calculated based on the proportion of positive responses ("strongly agree" and "agree") relative to the total number of respondents. This metric enables the identification of statistically significant differences in negative attitudes between groups of respondents. A hypothesis is considered confirmed if more than 60% of the measured p-values are below 0.05. The same criterion is applied to evaluate hypotheses reflecting the overall structure of respondents' answers.

The chosen methodological approach allows for a thorough examination of attitudes and differences between owners and managers regarding ESG. The results of this study contribute to a better understanding of entrepreneurial and managerial attitudes in the context of ESG, which can be valuable for the implementation and realization of further business activities related to ESG.

## 4. Results

The results of the research are presented in the following tables.

*Table 1: Responses of respondents to the question related to H1*

| <b>ST1: I consider ESG to be bureaucratic nonsense that hinders our business operations.</b> | <b>SR</b><br>The number/<br>proportion in<br>percentages | <b>CR</b><br>The number/<br>proportion in<br>percentages | <b>PL</b><br>The number/<br>proportion in<br>percentages | <b>HU</b><br>The number/<br>proportion in<br>percentages |
|----------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| 1. strongly agree                                                                            | 43/11.20                                                 | 42/10.80                                                 | 61/15.60                                                 | 66/17.14                                                 |
| 2. agree                                                                                     | 85/22.14                                                 | 75/19.28                                                 | 118/30.18                                                | 77/20.00                                                 |
| 3. neutral                                                                                   | 183/47.66                                                | 190/48.84                                                | 122/31.20                                                | 124/32.21                                                |
| 4. disagree                                                                                  | 39/10.16                                                 | 52/13.37                                                 | 49/12.53                                                 | 74/19.22                                                 |
| 5. Strongly disagree                                                                         | 34/8.85                                                  | 30/7.71                                                  | 41/10.49                                                 | 44/11.43                                                 |
| Total respondents                                                                            | 384                                                      | 389                                                      | 391                                                      | 385                                                      |

*Source: own elaboration*

The responses of respondents to the question of whether they consider ESG to be bureaucratic nonsense that hinders their business operations vary depending on the country. The most significant differences in positive responses were observed between the Czech Republic and Hungary, with a 6.34% difference in the "strongly agree" response. For the neutral response, the largest difference was recorded between the Czech Republic and Poland (17.64%), and for negative responses, the differences were between Slovakia and Hungary ("disagree" = 9.06%) and between the Czech Republic and Hungary ("strongly disagree" = 3.72%). The percentage differences in responses between other countries and statements are not particularly pronounced. In terms of the overall structure, neutral responses predominated in Slovakia and the Czech Republic, while positive responses were more common in Poland and Hungary. In summary, Polish and Hungarian respondents perceive ESG as bureaucratic nonsense that hinders their business, whereas Slovak and Czech respondents adopt a neutral stance toward this statement.

The results presented in Table 2 indicate that there are no statistically significant differences in the overall response structure between respondents from Slovakia and the Czech Republic (p-value = 0.584424). In all other country combinations under investigation, statistically significant differences in the overall response structure were identified. However, differing patterns emerged when analyzing the structure of positive responses. While a significant difference in the overall response structure was found between Slovakia and Hungary, no statistically significant difference was observed in the structure of positive responses

*Table 2: Statistically significant differences in the overall structure of responses and in the positive attitudes of respondents in the examined countries*

| ST1   | Absolute values of the Z-scores | Chi-square/p-value | Z-score/p-value |
|-------|---------------------------------|--------------------|-----------------|
| SR/CR | 128/117                         | 2.8431/0.584424    | 0.9728/0.33204  |
| SR/HU | 128/143                         | 28.7085/0.00001    | -1.1057/0.267   |
| SR/PL | 128/179                         | 22.4082/0.000166   | -3.5422/0.0004  |
| HU/CR | 143/117                         | 25.7022/0.000036   | 2.081/0.03752   |
| CR/PL | 117/179                         | 29.6941/0.00001    | -4.5188/0.00001 |
| HU/PL | 143/179                         | 13.9753/0.007374   | -2.4416/0.01468 |

*Source: own elaboration*

(p-value = 0.267). A p-value greater than 0.05 was also recorded in the case of Slovakia and the Czech Republic, where the p-value reached 0.33204, indicating the absence of statistically significant differences in respondents' positive attitudes toward the given statement. In contrast, statistically significant differences in positive attitudes were identified in the remaining country comparisons, specifically between Slovakia and Poland (p-value = 0.0004), Hungary and the Czech Republic (p-value = 0.03752), the Czech Republic and Poland (p-value = 0.00001), and Hungary and Poland (p-value = 0.01468). The number of p-values below the 0.05 threshold exceeds 60%. H1 was confirmed.

*Table 3: Statistically significant differences in respondents' positive attitudes across the examined countries by organizational position*

| ST1             | SR<br>by position | CR<br>by position | PL<br>by position | HU<br>by position |
|-----------------|-------------------|-------------------|-------------------|-------------------|
| Absolute values | 81/47             | 47/70             | 70/109            | 77/66             |
| Z-score/p-value | 0/1               | -0.5877/0.5552    | 0.2776/0.77948    | 3.927/0.00008     |

*Source: own elaboration*

Statistically significant differences in respondents' positive attitudes based on their position within the enterprise were identified in only one of the examined countries—specifically in Hungary, where the p-value was 0.00008. In the remaining three countries under study, respondents' views were similar regardless of whether they held the position of owner or manager within the enterprise. The proportion of p-values below the 0.05 threshold does not exceed 60%. Hypothesis H1a was rejected.

*Table 4: Respondents' answers to the question related to H2*

| ST2: I consider environmental protection to be excessive and believe it negatively affects our business operations. | SR<br>the number/<br>proportion in<br>percentages | CR<br>the number/<br>proportion in<br>percentages | PL<br>the number/<br>proportion in<br>percentages | HU<br>the number/<br>proportion in<br>percentages |
|---------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|
| 1. strongly agree                                                                                                   | 49/12.76                                          | 34/8.74                                           | 85/21.74                                          | 76/19.74                                          |
| 2. agree                                                                                                            | 92/23.96                                          | 88/22.62                                          | 92/23.53                                          | 97/25.19                                          |
| 3. neutral                                                                                                          | 120/31.25                                         | 137/35.22                                         | 88/22.51                                          | 82/21.30                                          |
| 4. disagree                                                                                                         | 76/19.79                                          | 92/23.65                                          | 74/18.93                                          | 94/24.42                                          |
| 5. Strongly disagree                                                                                                | 47/12.24                                          | 38/9.77                                           | 52/13.30                                          | 36/9.35                                           |
| Total respondents                                                                                                   | 384                                               | 389                                               | 391                                               | 385                                               |

*Source: own elaboration*

Respondents' answers within individual countries to statement ST2 were diverse, with approximately equal proportions of strongly agree and strongly disagree responses in Slovakia and the Czech Republic. In the other two countries, the response structures were more varied. In Slovakia, the majority of responses were in agreement (36.72%), while in the Czech Republic, neutral responses prevailed (33.42%). In Poland, the majority of respondents agreed with the statement (45.27%), as was also the case in Hungary (44.93%). From the perspective of majority response types, percentage shares, and cross-country comparison of respondent

answers, it can be inferred that the greatest similarities were observed between Poland and Hungary.

*Table 5: Statistically significant differences in the overall response structure and in the positive attitudes of respondents across the examined countries*

| ST2   | Absolute values of the Z-scores | Chi-square/p-value      | Z-score/p-value        |
|-------|---------------------------------|-------------------------|------------------------|
| SR/CR | 141/122                         | 6.3689/0.173239         | 1.5716/0.11642         |
| SR/HU | 141/173                         | <b>16.4752/0.002443</b> | <b>-2.3177/0.02034</b> |
| SR/PL | 141/177                         | <b>14.8119/0.005108</b> | <b>-2.4193/0.01552</b> |
| HU/CR | 173/122                         | <b>30.3427/0.00001</b>  | <b>3.8874/0.0001</b>   |
| CR/PL | 122/177                         | <b>36.7418/0.00001</b>  | <b>-3.994/0.00006</b>  |
| HU/PL | 173/177                         | 6.0912/0.192443         | -0.0933/0.92828        |

*Source: own elaboration*

The results presented in Table 5 indicate that no significant differences in the overall response structure were observed between Slovakia and the Czech Republic (p-value = 0.173239) and between Hungary and Poland (p-value = 0.192443). In the remaining country comparisons, statistically significant differences in respondents' overall response structure concerning statement ST2 were identified. This suggests that in most of the countries under examination, respondents do not share a common view on the issue of environmental protection. A similar pattern was observed in the structure of positive responses, with no significant differences recorded between Slovakia and the Czech Republic (p-value = 0.11642) and between Hungary and Poland (p-value = 0.92828). The proportion of p-values below the 0.05 threshold exceeds 60%. Hypothesis H2 was confirmed.

*Table 6: Statistically significant differences in respondents' positive attitudes across the examined countries based on their position within the enterprise*

| ST2             | SR<br>by position | CR<br>by position | PL<br>by position | HU<br>by position |
|-----------------|-------------------|-------------------|-------------------|-------------------|
| Absolute values | 86/55             | 52/70             | 70/107            | 79/94             |
| Z-score/p-value | -0.7086/0.4777    | 0.0557/0.95216    | 0.4382/0.65994    | 1.6668/0.09492    |

*Source: own elaboration*

The potential existence of differences in responses to the given statement was also examined with respect to the respondents' position within the enterprise. When analyzing the differences between owners and managers, no statistically significant differences in positive attitudes toward the statement were identified in any of the countries under study. The proportion of p-values below the 0.05 threshold does not exceed 60%. Hypothesis H2a was rejected.

*Table 7: Respondents' answers to the question related to H3*

| ST3: We do not consider relationships with the community to be important. For us, survival in the market is the priority. | SR<br>the number/<br>proportion in<br>percentages | CR<br>the number/<br>proportion in<br>percentages | PL<br>the number/<br>proportion in<br>percentages | HU<br>the number/<br>proportion in<br>percentages |
|---------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|
| 1. strongly agree                                                                                                         | 50/13.02                                          | 43/11.05                                          | 70/17.90                                          | 81/21.04                                          |
| 2. agree                                                                                                                  | 112/29.17                                         | 106/27.25                                         | 128/32.74                                         | 119/30.91                                         |
| 3. neutral                                                                                                                | 105/27.34                                         | 109/28.02                                         | 89/22.76                                          | 66/17.14                                          |
| 4. disagree                                                                                                               | 86/13.02                                          | 104/8.23                                          | 63/9.72                                           | 89/23.12                                          |
| 5. Strongly disagree                                                                                                      | 31/8.07                                           | 27/2.31                                           | 41/8.44                                           | 30/7.79                                           |
| Total respondents                                                                                                         | 384                                               | 389                                               | 391                                               | 385                                               |

*Source: own elaboration*

The next statement examined focused on the relationship between businesses and their communities. Respondents' answers reflecting their attitudes toward this statement are presented in Table 7. In all the countries under study, most responses agreed with the statement.

Based on these findings, it can be inferred that respondents do not consider relationships with the community to be important. The structure of strongly agree responses is similar in Slovakia and the Czech Republic, with a difference of only 1.97%, and likewise in Poland and Hungary, where the difference is 3.14%. For neutral responses, the percentage across all countries ranges from 27% to 33%. A comparable pattern is also observed in the structure of strongly disagree responses between Poland and Hungary, where the difference is minimal (0.65%). However, a more pronounced difference (10.38%) is observed between Slovakia and the Czech Republic in this category. Overall, it can be concluded that in all the countries examined, respondents do not perceive relationships with the community as important. It may also be assumed that no significant differences are likely to arise between Slovakia and the Czech Republic or between Poland and Hungary.

*Table 8: Statistically significant differences in the overall response structure and in the positive attitudes of respondents across the examined countries*

| ST3   | Absolute values of the Z-scores | Chi-square/p-value | Z-score/p-value |
|-------|---------------------------------|--------------------|-----------------|
| SR/CR | 162/149                         | 2.7157/0.606473    | 1.2482/0.2113   |
| SR/HU | 162/200                         | 16.5093/0.002407   | -2.7113/0.00672 |
| SR/PL | 162/198                         | 10.5965/0.031494   | -2.3588/0.01828 |
| HU/CR | 200/149                         | 24.2657/0.000071   | 3.8145/0.00014  |
| CR/PL | 149/198                         | 23.4832/0.000101   | -3.4664/0.00052 |
| HU/PL | 200/198                         | 10.648/0.030818    | 0.3647/0.71884  |

*Source: own elaboration*

The results related to the examination of differences between countries are presented in Table 8. Based on these findings, the previously stated assumption was confirmed—no statistically significant differences in the overall response structure were found between Slovakia and the Czech Republic (p-value = 0.606473). In the remaining country comparisons, statistically significant differences in respondents' answers were observed. Regarding the structure of positive responses, no statistically significant differences were found between Slovakia and the Czech Republic (p-value = 0.2113), nor between Hungary and Poland (p-value = 0.71884). In all other cases, statistically significant differences in respondents' positive attitudes toward the given statement were identified. The proportion of p-values below the 0.05 threshold exceeds 60%. Hypothesis H3 was confirmed.

*Table 9: Statistically significant differences in the positive attitudes of respondents across the examined countries based on their position within the enterprise*

| ST3             | SR<br>by position | CR<br>by position | PL<br>by position | HU<br>by position |
|-----------------|-------------------|-------------------|-------------------|-------------------|
| Absolute values | 108/54            | 67/82             | 83/115            | 95/105            |
| Z-score/p-value | 1.1756/0.238      | 0.8018/0.42372    | 1.4646/0.1443     | 2.6797/0.00736    |

*Source: own elaboration*

Statistically significant differences in the positive attitudes of owners and managers were identified in only one of the countries under study—specifically in Hungary, where the p-value reached 0.00736. In the remaining countries, no statistically significant differences in positive attitudes were observed based on respondents' positions within the enterprise. It can be concluded that the views of owners and managers in Slovakia, the Czech Republic, and Poland regarding the company's relationship with the community are similar. The proportion of p-values below the 0.05 threshold does not exceed 60%. Hypothesis H3a was rejected.

The final statement examined concerns corporate sustainability. Table 10 presents the structure of respondents' answers across the countries under study. In all countries, most responses agreed with the statement. In Slovakia, 46.87% of respondents agreed with the statement, in the Czech Republic 37.02%, in Poland 50.39%, and in Hungary 49.09%. The

*Table 10: Respondents' answers to the question related to H4*

| <b>ST4: Sustainability is not a key issue for our company. Our current priority is to survive in the market.</b> | <b>SR</b><br>the number/<br>proportion in<br>percentages | <b>CR</b><br>the number/<br>proportion in<br>percentages | <b>PL</b><br>the number/<br>proportion in<br>percentages | <b>HU</b><br>the number/<br>proportion in<br>percentages |
|------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| 1. strongly agree                                                                                                | 49/12.76                                                 | 46/11.83                                                 | 81/20.72                                                 | 85/22.08                                                 |
| 2. agree                                                                                                         | 131/34.11                                                | 98/25.19                                                 | 116/29.67                                                | 104/27.01                                                |
| 3. neutral                                                                                                       | 117/30.47                                                | 137/35.22                                                | 105/26.85                                                | 71/18.44                                                 |
| 4. disagree                                                                                                      | 58/15.10                                                 | 75/19.28                                                 | 56/14.32                                                 | 78/20.26                                                 |
| 5. Strongly disagree                                                                                             | 29/7.55                                                  | 33/8.48                                                  | 33/8.44                                                  | 47/12.21                                                 |
| Total respondents                                                                                                | 384                                                      | 389                                                      | 391                                                      | 385                                                      |

*Source: own elaboration*

highest level of agreement was recorded in Poland, though the difference compared to Slovakia and Hungary is not substantial. The most pronounced difference in the structure of positive responses was observed between Poland and the Czech Republic (13.37%). Among all countries, the Czech Republic had the highest proportion of neutral responses. Based on these findings, it may be assumed that respondents from all the examined countries are more inclined to consider corporate sustainability as a secondary concern compared to their current market situation, position, and market share.

*Table 11: Statistically significant differences in the overall structure of responses and in the positive attitudes of respondents across the countries under study*

| <b>ST4</b> | <b>Absolute values of the Z-scores</b> | <b>Chi-square/p-value</b> | <b>Z-score/p-value</b> |
|------------|----------------------------------------|---------------------------|------------------------|
| SR/CR      | 180/144                                | 8.824/0.065652            | 2.777/0.00544          |
| SR/HU      | 180/189                                | 31.2322/0.00001           | -0.615/0.54186         |
| SR/PL      | 180/197                                | 9.6672/0.046422           | -0.9771/0.32708        |
| HU/CR      | 189/144                                | 35.2203/0.00001           | 3.3919/0.0007          |
| CR/PL      | 144/197                                | 18.1418/0.001158          | -3.7626/0.00016        |
| HU/PL      | 189/197                                | 13.3355/0.009748          | -0.3601/0.71884        |

*Source: own elaboration*

Based on the p-values presented in Table 11, it was determined that no statistically significant differences in the overall response structure were observed between Slovakia and the Czech Republic (p-value = 0.065652). In all other country comparisons, statistically significant differences in the overall response structure were identified. However, a shift is observed in the structure of positive responses and the presence of statistically significant differences in this regard. Statistically significant differences in the structure of positive responses were recorded between Slovakia and the Czech Republic (p-value = 0.00544), Hungary and the Czech Republic (p-value = 0.0007), and the Czech Republic and Poland (p-value = 0.00016). In the remaining country comparisons, no statistically significant differences in positive response structures were found. The proportion of p-values below the 0.05 threshold exceeds 60%. Hypothesis H4 was confirmed.

*Table 12: Statistically significant differences in the positive attitudes of respondents across the countries under study based on their position within the enterprise*

| <b>ST4</b>      | <b>SR</b><br>by position | <b>CR</b><br>by position | <b>PL</b><br>by position | <b>HU</b><br>by position |
|-----------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Absolute values | 129/51                   | 58/86                    | 77/120                   | 91/98                    |
| Z-score/p-value | 3.2021/0.00138           | -0.6543/0.5157           | 0.2963/0.76418           | 2.7847/0.00544           |

*Source: own elaboration*

Statistically significant differences in the positive attitudes of owners and managers were examined using Z-scores, the values of which are presented in Table 12. Based on these values, statistically significant differences in positive attitudes between business owners and managers

were found in Slovakia (p-value = 0.00138) and Hungary (p-value = 0.00544). In contrast, no statistically significant differences were observed in the Czech Republic (p-value = 0.5157) or Poland (p-value = 0.76418). The proportion of p-values below the 0.05 threshold does not exceed 60%. Hypothesis H4a was rejected.

The research conducted in the Visegrád Group (V4) countries focused on analyzing the negative attitudes of SME owners and managers towards selected aspects of ESG. Respondents expressed their views on statements related to bureaucracy, environmental care, community relations, and corporate sustainability. The results demonstrated the existence of statistically significant differences between the countries; however, no statistically significant differences attributable to respondents' positions within the company were observed for any of the aspects. Overall, it can be concluded that while statistically significant differences exist in the overall response structures between countries, such differences were not found in the positive response patterns between owners and managers.

## **5. Discussion**

The results of the conducted research provide important empirical evidence of the existence of negative attitudes towards the implementation of ESG principles within small and medium-sized enterprises (SMEs) in the V4 countries. Respondents from Poland and Hungary exhibited a higher degree of agreement with the statement that ESG represents a bureaucratic burden or excessive environmental regulation that negatively affects business operations. In contrast, responses from Slovakia and the Czech Republic were predominantly neutral. These findings align with those of Rizos et al. (2016), who identified that SMEs in countries with lower institutional support and limited ESG awareness often perceive such initiatives as external constraints rather than strategic opportunities.

The observed differences in ESG perception between countries can be further interpreted in the context of national cultural and business specificities. As highlighted by Acheampong et al. (2025), SMEs in Eastern European countries face deficits in ESG education and access to expert capacities, which reduce their ability to integrate ESG into strategic management. In our research, these limitations are also reflected in the strong agreement with statements indicating that community relations and corporate sustainability are not priorities for businesses, pointing to a focus on short-term survival rather than long-term sustainability.

A significant finding of the study is the absence of consistent statistically significant differences in ESG-related attitudes between owners and managers. Although some countries (e.g., Hungary) exhibited differences in responses to individual statements, it can be generally affirmed that ESG perception is not markedly influenced by organizational role. This result corresponds with the findings of Sindhwani et al. (2022), who argue that in the absence of a systematic ESG strategy, attitudes towards these issues are dispersed across organizational structures and are not exclusively tied to ownership or management positions.

The findings related to the environmental and social pillars of ESG also correspond with the conclusions of Han and Lee (2024), who report that insufficient corporate preparedness and pressure for rapid ESG transformation can induce so-called “ESG stress” among employees. This stress subsequently manifests in reduced job satisfaction, internal resistance to change, and increased turnover rates.

## 6. Conclusions

This article focuses on identifying and analyzing the negative aspects of implementing ESG (Environmental, Social, and Governance) principles in the small and medium-sized enterprise (SME) sector within the Visegrád Group (V4) countries, with a specific emphasis on comparing the attitudes of owners and managers. The research aimed to verify the extent to which respondents' attitudes differ based on their country of origin and organizational position, focusing on four key areas: the perception of ESG as an administrative burden, attitudes towards environmental sustainability, the importance of community relations, and the prioritization of sustainable development as a strategic goal.

The empirical research, conducted in May 2025, was based on quantitative survey data collected from 1,549 respondents within SMEs across four countries (Slovakia, Czech Republic, Poland, Hungary). Statistical hypothesis testing using chi-square tests and Z-scores at a significance level of  $p = 0.05$  demonstrated significant differences between countries but only marginal differences according to respondents' organizational positions. The most negative attitudes towards ESG were observed among respondents from Poland and Hungary, whereas Slovak and Czech respondents exhibited a higher degree of neutrality.

The results indicate that the barriers to ESG implementation in SMEs are not primarily driven by internal differences between owners and managers, but rather by structural and cultural factors at the national business environment level. These findings highlight the need for targeted support for ESG transformation through public policies, particularly via education, advisory services, and simplification of the legislative framework.

Future research should expand the scope to include additional Central and Eastern European countries and incorporate qualitative approaches to gain deeper insights into the psychological and value-based mechanisms underlying resistance to ESG. Additionally, investigating causal relationships between the degree of ESG integration and indicators of business performance and employee stability could enrich current knowledge about the benefits and risks of ESG practices in SMEs.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Acknowledgments:** The paper is an output of the project VEGA: 1/0109/25 The theoretical model of ESG in the SME segment in the V4 countries.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

- Abu Hassan, M., Shari, W., Wahab, N., Asmaa, A., Ezanee, M., Maimun, N., & Wahab, A. (2023). Towards Sustainable Small and Medium Enterprises (SMEs): Awareness and Overcoming Challenges. *Asia-Pacific Management Accounting Journal*, 18(3), 165–197.
- Acheampong, O., Taurigana, V., Asare, N., & Okyere, G. A. (2025). Sustainability Reporting Determinants: A Systematic Review of Trends, Challenges, and Opportunities. *Journal of African Business*, 1–33. <https://doi.org/10.1080/15228916.2024.2449282>

- Agbulut, U., Karagoz, M., Saridemir, S., & Ozturk, A. (2020). Impact of various metal-oxide based nanoparticles and biodiesel blends on the combustion, performance, emission, vibration and noise characteristics of a CI engine. *Fuel*, 270, 117521. <https://doi.org/10.1016/j.fuel.2020.117521>
- Belas, J., Balcerzak, A.-P., Dvorsky, J., & Streimikis, J. (2024). Influencing ESG perception in SMEs through CSR, business ethics, and HRM: An empirical study in V4 countries. *Amfiteatru Economic*, 26(66), 532–547. <https://doi.org/10.24818/EA/2024/66/532>
- Burke, J.-J. (2022). Do boards take environmental, social, and governance issues seriously? Evidence from media coverage and CEO dismissals. *Journal of Business Ethics*, 176(4), 647–671.
- Cai, X., Xiang, H., Neskorođieva, I., & Durmanov, A. (2024). Interrelation between human capital management and ESG engagement: Evidence from S&P 500 firms. *Humanities and Social Sciences Communications*, 11(1), 1654. <https://doi.org/10.1057/s41599-024-04189-6>
- Camelo, G., & Nogueira, M. (2024). The ESG Menu: Integrating Sustainable Practices in the Portuguese Agri-Food Sector. *Sustainability*, 16(11), 4377. <https://doi.org/10.3390/su16114377>
- Chen, Y., Cheng, C.A., Li, S. and Zhao, J. (2020), The monitoring role of the media: evidence from earnings management. *Journal of Business Finance and Accounting*, 48(3-4), 533-563. <https://doi.org/10.1111/jbfa.12490>
- Durrani, N., Raziq, A., Mahmood, T., & Khan, M. R. (2024). Barriers to adaptation of environmental sustainability in SMEs: A qualitative study. *Plos one*, 19(5), e0298580. <https://doi.org/10.1371/journal.pone.0298580>
- Ganc, M., & Felczak, T. (2025). Sustainability Reporting in the Opinion of Managers in Food Companies in Poland. *Sustainability*, 17(7), 3075. <https://doi.org/10.3390/su17073075>
- Garrido-Ruso, M., Otero-González, L., Lopez-Penabad, M. C., & Santomil, P. D. (2024). Does ESG implementation influence performance and risk in SMEs?. *Corporate Social Responsibility and Environmental Management*, 31(5), 4227-4247. [tps://doi.org/10.1002/csr.2783](https://doi.org/10.1002/csr.2783)
- Garsaa, A., & Paulet, E. (2023). ESG Disclosure and Employee Turnover. New Evidence from Listed European Companies. *Relations industrielles-Industrial Relations*, 77(4). <https://doi.org/10.7202/1097695ar>
- Han, G.-R., & Lee, J.-E. (2024). Does ESG Affect Mental Health of Employees? Focusing on the Moderating Effects of Job Crafting and Relationship Conflict. *Sustainability*, 16(14), 6076. <https://doi.org/10.3390/su16146076>
- Hrnjica, E., Veselinovic, L., & Cinjarevic, M. (2024). Exploring managerial intentions to implement ESG Activities: The role of facilitating conditions in the UTAUT2 framework. *Regional Science Policy & Practice*, 16(10), 100126. <https://doi.org/10.1016/j.rssp.2024.100126>
- Huang, Y.-F., Chen, A. P.-S., Do, M.-H., & Chung, J.-C. (2022). Assessing the Barriers of Green Innovation Implementation: Evidence from the Vietnamese Manufacturing Sector. *Sustainability*, 14(8), 4662. <https://doi.org/10.3390/su14084662>
- Hussaini, M., Rigoni, U., & Perego, P. (2023). The strategic choice of payment method in takeovers: The role of environmental, social and governance performance. *Business Strategy and the Environment*, 32(1), 200–219. <https://doi.org/10.1002/bse.3125>
- Jamaludin, A. F., Husain, M. F. H., & Razali, M. N. (2025). Assessing environmental, social and governance of property-listed companies in Malaysia. *Property Management*. <https://doi.org/10.1108/PM-03-2024-0022>
- Khurram, M. U., Chen, L., Abedin, M. Z., Adu, D. A., & Lucey, B. (2024). ESG disclosure and internal pay gap: Empirical evidence from China. *International Review of Economics & Finance*, 92, 228–244. <https://doi.org/10.1016/j.iref.2024.02.023>
- Li, M., & Chen, Q. (2024). Executive pay gap and corporate ESG greenwashing: Evidence from China. *International Review of Financial Analysis*, 95, 103375. <https://doi.org/10.1016/j.irfa.2024.103375>
- Liou, J. J. H., Liu, P. Y. L., & Huang, S.-W. (2023). Exploring the key barriers to ESG adoption in enterprises. *Systems and Soft Computing*, 5, 200066. <https://doi.org/10.1016/j.sasc.2023.200066>
- Liu, Y., She, Y., Liu, S., & Lan, H. (2022). Supply-shock, demand-induced or superposition effect? The impacts of formal and informal environmental regulations on total factor productivity of Chinese agricultural enterprises. *Journal of Cleaner Production*, 380, 135052. <https://doi.org/10.1016/j.jclepro.2022.135052>
- Meng, T., Lu, D., Yu, D., Yahya, M. H., & Zariyawati, M. A. (2024). Is executive compensation aligned with the company's ESG objectives? Evidence from Chinese listed companies based on the PSM-DID approach. *Humanities and Social Sciences Communications*, 11(1), 1560. <https://doi.org/10.1057/s41599-024-04094-y>
- Piao, X., Xie, J., & Managi, S. (2022). Environmental, social, and corporate governance activities with employee psychological well-being improvement. *BMC Public Health*, 22(1), 22. <https://doi.org/10.1186/s12889-021-12350-y>
- Rizos, V., Behrens, A., van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papadelis, S., Hirschnitz-Garbers, M., & Topi, C. (2016). Implementation of circular economy business models

- by small and medium-sized enterprises (SMEs): Barriers and enablers. *Sustainability*, 8(11), 1212. <https://doi.org/10.3390/su8111212>
- Rumyantseva, A., & Tarutko, O. (2022). Impact of the ESG Principles on the Corporate Financial Strategy. *Challenges and Solutions in the Digital Economy and Finance*, 309-318. Springer International Publishing. [https://doi.org/10.1007/978-3-031-14410-3\\_32](https://doi.org/10.1007/978-3-031-14410-3_32)
- Setyaningsih, S., Widjojo, R., & Kelle, P. (2024). Challenges and opportunities in sustainability reporting: a focus on small and medium enterprises (SMEs). *Cogent Business & Management*, 11(1), 2298215. <https://doi.org/10.1080/23311975.2023.2298215>
- Shalhoob, H., & Hussainey, K. (2023). Environmental, Social and Governance (ESG) Disclosure and the Small and Medium Enterprises (SMEs) Sustainability Performance. *Sustainability*, 15(1), 200. <https://doi.org/10.3390/su15010200>
- Sindhwani, R., Singh, P. L., Behl, A., Afridi, Mohd. S., Sammanit, D., & Tiwari, A. K. (2022). Modeling the critical success factors of implementing net zero emission (NZE) and promoting resilience and social value creation. *Technological Forecasting and Social Change*, 181, 121759. <https://doi.org/10.1016/j.techfore.2022.121759>
- Tumwebaze, Z., Bananuka, J., Orobia, L. A., & Kinatta, M. M. (2022). Board role performance and sustainability reporting practices: Managerial perception-based evidence from Uganda. *Journal of Global Responsibility*, 13(3), 317-337. <https://doi.org/10.1108/JGR-08-2021-0072>
- Ullah, S., Ahmad, N., Khan, F. U., Badulescu, A., & Badulescu, D. (2021). Mapping Interactions among Green Innovations Barriers in Manufacturing Industry Using Hybrid Methodology: Insights from a Developing Country. *International Journal of Environmental Research and Public Health*, 18(15), 7885. <https://doi.org/10.3390/ijerph18157885>
- Zhang, Z. and Cheng, H. (2020), Media coverage and impression management in corporate social responsibility reports: evidence from China. *Sustainability Accounting, Management and Policy Journal*, 11(5), 863-886. <https://doi.org/10.1108/SAMPJ-10-2018-0293>

## EVALUATING FINANCIAL STABILITY AND PREDICTIVE MODELLING OF SME PROSPERITY IN MANUFACTURING

Veronika Kusnierikova<sup>1,a</sup>, Simona Vojtekova<sup>1,b,\*</sup> and Sheshadri Chatterjee<sup>2,c</sup>

<sup>1</sup> Department of Economics, Faculty of Operation and Economics of Transport and Communications,  
University of Zilina, Univerzitna 1, 010 26 Zilina, Slovakia

<sup>2</sup> Department of Management, Indian Institute of Information Technology, Lucknow, 226002, India

<sup>a</sup>kusnierikova3@stud.uniza.sk,

<sup>b</sup>simona.vojtekova@stud.uniza.sk,

<sup>c</sup>sheshadri.academic@gmail.com

\*Corresponding author

**Cite as:** Kusnierikova, V., Vojtekova, S., Chatterjee, S. (2025). Evaluating financial stability and predictive modelling of SME prosperity in manufacturing, *Ekonomicko-manazerske spektrum*, 19(1), 83-96.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.83-96](https://dx.doi.org/10.26552/ems.2025.1.83-96)

---

Received: 7 February 2025; Received in revised form: 30 April 2025; Accepted: 30 May 2025; Available online: 30 June 2025

### Abstract:

**Research background:** This study evaluates the financial stability of small and medium-sized enterprises (SMEs) within Slovak manufacturing, classified under NACE C. The sector, which is characterised by the physical or chemical transformation of materials into new products, represents a significant part of the Slovak economy. The analysis uses financial data from the FinStat database covering the period 2018–2023, focusing on key financial ratios related to activity, liquidity, profitability, and indebtedness.

**Purpose of the article:** The main aim of this paper is to assess the financial health of SMEs in Slovak manufacturing and to develop a predictive model that identifies financially distressed firms using key financial ratios.

**Methods:** A sample of 1,848 firms continuously observed over six years was analysed to assess temporal changes in financial performance indicators using median values. Statistical significance was tested via the non-parametric Friedman test, revealing that all selected financial ratios were influenced by time. Indicators such as assets turnover, cash ratio, return on equity, and indebtedness ratios demonstrated notable fluctuations, reflecting shifts in firms' operational and financial health. Furthermore, the study developed a predictive model for financial health in 2023 based on 2022 financial indicators through discriminant analysis. The model classified firms as prosperous or non-prosperous based on the equity-to-liabilities ratio.

**Findings & Value added:** Key predictors included the self-financing ratio, financial leverage, commercial insolvency ratio, current ratio, return on equity, and creditors' payment period. The model achieved a high classification accuracy of 91.2%, correctly identifying 96.1% of prosperous and 86.3% of non-prosperous enterprises. The model's excellent predictive capability was further confirmed by the ROC curve analysis, yielding an area under the curve (AUC) of 0.952. These results highlight the model's effectiveness in forecasting financial health for manufacturing SMEs in the post-COVID context in Slovakia.

**Keywords:** corporate finance; financial health; NACE C; prediction model; SMEs

**JEL Classification:** G17; G33; L60

## **1. Introduction**

Financial analysis is a fundamental component of corporate financial management. A crucial element of financial analysis is utilising previous data on a company's performance to predict its future economic growth (Jencova et al., 2021). Financial and economic analysis functions as a feedback mechanism that enables a corporation to assess the effectiveness of its decisions, regardless of whether they fulfilled initial expectations (Podhorska and Siekelova, 2020).

The assessment of a company's financial health is a complex endeavour that necessitates an emphasis on liquidity, activity, indebtedness, and profitability, each offering distinct perspectives on the company's capacity to fulfil its obligations, the efficiency of asset utilisation, the composition of financial resources, and overall performance. Improved financial health is associated with enhanced financial success and vice versa (Das et al., 2024).

The study examines activity, liquidity, debt, and profitability. The rationale for employing four distinct types of indicators is that a single indicator is inadequate for evaluating a company's financial health and performance (Jihadi et al., 2021). Activity indicators reflect the efficacy of management about a company's assets, often representing the capital invested in assets/liabilities, asset turnover, or turnover period. Effective corporate management is essential for minimising expenses and establishing conditions conducive to profit generation. Efficiency is a fundamental criterion for evaluating a company's financial health. The method of asset management significantly influences both growth and the reduction of profit. It also elucidates the positioning of enterprises within a competitive market landscape (Durana et al., 2025).

Liquidity analysis provides results that indicate a company's capacity to fulfil its obligations punctually. A financially sound corporation can meet its obligations, but a company in financial distress encounters challenges in doing so. Consequently, it is essential to sustain the company's liquidity at an appropriate level. To maintain perpetual solvency, or liquidity, a corporation must consistently analyse, monitor, and assess its liquidity (Stangova and Vighova, 2021).

From the owner's perspective, profitability indicators are regarded as the most significant ratio metrics. Profitability indicators serve to assess the outcomes of company endeavours (Bugaj et al., 2023).

Debt analysis involves monitoring the ratio of equity to debt inside a corporation, which affects financial stability and the profitability of stock. An increased equity ratio establishes the conditions for enhanced financial independence and stability of the organisation. Utilising debt may enhance the profitability of equities via financial leverage. Elevated debt levels augment the cost of borrowing, resulting in corporate instability and the onset of liquidity issues, as interest obligations on loan capital must also be fulfilled. Monitoring debt is a crucial aspect of a firm's financial success, particularly when the company lacks sufficient equity. Nonetheless, escalating debt might provide a challenging financial predicament for a corporation, manifesting as insolvency and an incapacity to meet its forthcoming obligations (Culkova et al., 2018; Valaskova et al., 2021; Gajdosikova et al., 2023).

The number of financial performance indicators of a company is almost infinite, so it is necessary to select those that best serve the purpose of the analysis (Durana et al., 2024; Kumar et al., 2022). In assessing a company's financial health, we utilise terminology such as failure, insolvency, and bankruptcy. Currently, we have a contradiction in the interpretation of these words at both economic and legal levels, and there is also discord in the professional literature over their meanings (Kliestik et al., 2019).

The initial research on forecasting corporate insolvency was published in the early 20th century (Valaskova et al., 2023). The obstacle of forecasting a company's financial situation, namely the risk of financial distress, is crucial not only for management to implement necessary actions but also for all stakeholders to understand the company's financial health and potential future status. Presently, there exist several hundred to thousands of predictive models developed at times, utilising certain samples, and under distinct economic situations. This advancement is always evolving and gaining traction owing to advancements in computer technology (Pavlicko et al., 2021).

In the contemporary economy, securing the financial stability of an organisation and enhancing its competitiveness is notably challenging. Researchers must use old and contemporary measurements to assess the economic sustainability of firms. Assessing the financial status of an organisation and forecasting its future trajectory is essential. Consequently, the pursuit of effective models for forecasting bankruptcy is crucial not only in academic research but also in the operations of corporate organisations (Jencova et al., 2024).

Once more, while categorising methodologies for forecasting the financial stability of corporations, we observe several classifications from many authors. Klietik et al. (2019) categorise methodologies or models into the following: univariate models, multiple discriminant analysis, linear probability models, LOGIT and PROBIT models, decision trees, survival analysis, expert systems, mathematical programming, neural networks, genetic algorithms and fuzzy sets.

Small and medium-sized enterprises represent a fundamental pillar of the modern economy, whose importance goes beyond their individual dimensions and aggregates into macroeconomic benefits. SMEs play a multifaceted role, primarily manifesting in four key dimensions. They are the primary generator of employment and a catalyst for social cohesion, while in many economies they constitute most enterprises and absorb a significant share of the workforce. This phenomenon has a direct impact on unemployment rates and income distribution, thereby contributing to the stabilization of society and the reduction of social disparities (Chatterjee et al., 2022b). At the same time, they represent a dynamic source of innovation and technological progress. Thanks to their flexibility, agility and often less rigid organizational structure, SMEs can respond more quickly to market stimuli and implement new ideas (Chatterjee et al., 2022a). This incubation capacity for innovation is critical to sustaining the competitiveness of national economies at the global level (Chatterjee et al., 2023a). In addition, SMEs strengthen local and regional economic resilience. Their anchoring in local communities leads to the reinvestment of capital in each geographical area and to the strengthening of local supply-demand chains. This decentralized economic model contributes to the diversification of risk and the reduction of dependence on a few large corporations, thereby increasing the overall robustness of the economy (Chatterjee et al., 2021). Finally, they are an essential element for the structural adaptability of the economy. In the context of dynamically changing market conditions and unexpected external shocks, the ability of SMEs to quickly adapt to new challenges is invaluable (Chatterjee et al., 2023b). Their ability to transform their business models and respond to shifts in demand allows the economy to navigate through crises more effectively and ensure sustainable development (Chaudhuri et al., 2022).

That is why it is necessary to map the financial health of SMEs in each sector, especially in those with a significant share in the economy. The goal of this article is to assess the financial health of SMEs in Slovak manufacturing and to develop a predictive model that identifies financially distressed firms using key financial ratios.

The article is structured as follows: The introduction focuses on research incentives and the significance of SMEs. Methodology describes the used indicators, analysed period and methods

run to detect the impact of the time and to create a prediction model. Results show specific median values for individual indicators and significant indicators within the classification of prosperous and non-prosperous enterprises. Discussion compared the results of the similar investigations. The conclusions sum up the limitations and future ways to explore.

## 2. Methodology

The study encompasses an evaluation of the financial stability of small and medium-sized firms within the chosen sector. The chosen sector is derived from the statistical classification of economic activities, it is NACE C, which denotes manufacturing. This area encompasses the physical or chemical alteration of materials, substances, or components into novel products. This segment is the most prominent and advanced within the context of economic activity in Slovakia, which is the reason for its selection by us (SK NACE, 2025).

The input data is derived from the financial statements of companies acquired from the FinStat database. These are small and medium-sized firms classified under NACE C. The quantity of firms has fluctuated in certain years (Table 1). These enterprises were used to compute median values of indicators.

*Table 1: Sample of enterprises*

| years                                 | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|---------------------------------------|-------|-------|-------|-------|-------|-------|
| Number of business entities in NACE C | 2,844 | 2,879 | 2,798 | 2,798 | 2,857 | 2,761 |

*Source: own elaboration*

During the observed period, it can be asserted that there were minor fluctuations in the number of firms under NACE C. The fluctuations in the number of firms may be attributed to the formation of new entities and the dissolution of existing ones within specific sectors.

$$\text{Assets turnover} = \frac{\text{sales}}{\text{average assets}} \quad (1)$$

$$\text{Assets turnover period} = \frac{\text{average assets}}{\text{sales}} \cdot 365 \quad (2)$$

$$\text{Inventory turnover} = \frac{\text{sales}}{\text{average inventory}} \quad (3)$$

$$\text{Inventory turnover period} = \frac{\text{average inventory}}{\text{sales}} \cdot 365 \quad (4)$$

$$\text{Collection period ratio} = \frac{\text{average receivables}}{\text{sales}} \cdot 365 \quad (5)$$

$$\text{Credit period ratio} = \frac{\text{average liabilities}}{\text{operating costs}} \cdot 365 \quad (6)$$

$$\text{Cash ratio} = \frac{\text{cash and equivalents}}{\text{short term liabilities}} \quad (7)$$

$$\text{Quick ratio} = \frac{\text{cash and equivalents} + \text{short term receivables}}{\text{short term liabilities}} \quad (8)$$

$$\text{Current ratio} = \frac{\text{cash and equivalents} + \text{short term receivables} + \text{inventory}}{\text{short term liabilities}} \quad (9)$$

$$\text{Return on equity} = \frac{\text{EAT}}{\text{equity}} \cdot 100 \quad (10)$$

$$\text{Return on assets} = \frac{\text{EAT}}{\text{total assets}} \cdot 100 \quad (11)$$

$$\text{Return on sales} = \frac{\text{EAT}}{\text{sales}} \cdot 100 \quad (12)$$

$$\text{Total indebtedness ratio} = \frac{\text{total liabilities}}{\text{total assets}} \cdot 100 \quad (13)$$

$$\text{Self financing ratio} = \frac{\text{equity}}{\text{total assets}} \cdot 100 \quad (14)$$

$$\text{Long term indebtedness ratio} = \frac{\text{long term liabilities}}{\text{total assets}} \cdot 100 \quad (15)$$

$$\text{Short term indebtedness ratio} = \frac{\text{short term liabilities}}{\text{total assets}} \cdot 100 \quad (16)$$

$$\text{Financial leverage ratio} = \frac{\text{total assets}}{\text{equity}} \quad (17)$$

$$\text{Commercial insolvency ratio} = \frac{\text{commercial liabilities}}{\text{commercial receivables}} \quad (18)$$

$$\text{Total insolvency ratio} = \frac{\text{short term liabilities}}{\text{short term receivables}} \quad (19)$$

$$\text{Interest coverage ratio} = \frac{\text{EBIT} + \text{interest paid}}{\text{interest paid}} \quad (20)$$

The study examines the examination of ratio indicators and the impact of time on their value. In the analysed period from 2018 to 2023, chosen indicators of activity, liquidity, profitability, and indebtedness for NACE C were examined among the ratio indicators. The examination of indicators, their developmental comparison, and subsequent interpretation are conducted based on the computed median values for the specified segment.

The examination of the time influence on the value of ratio indicators utilises the computed values from the sample set, especially the values of 1848 firms that were included in the sample sets for the full monitored period from 2018 to 2023. The significance level for the subsequent statistical tests is set at  $\alpha = 0.05$ . The computations are executed with the IBM SPSS Statistics 26 software. In the event of a breach of the assumptions of normal distribution, independence of samples, and homoscedasticity, one may employ a non-parametric ANOVA test for dependent samples, known as the Friedman test.

Development of the hypotheses for the Friedman test:

$H_0$ : The distribution of values remains consistent over all years. The value of the chosen indicators is unaffected by time.

$H_1$ : A minimum of two distributions exhibits positional differences. Time influences the valuation of the chosen metrics.

Discriminant analysis assesses whether the categorisation of a dependent variable (Y) is influenced by at least one independent variable (X). Utilising data from 2022, financial health in 2023 was forecasted by discriminant analysis and the stepwise technique. The independent variables consist of 20 indicators that were analysed and computed for the year 2022. The dependent variable is prosperity, as assessed inside a company in crisis in 2023.

A company in crisis is based on Slovak legislation according to Act 513/1991 Coll—Commercial Code. If the equity to liabilities ratio is more than or equal to 0.08, the firm is prosperous. In the second scenario, if the value of the specified ratio is below 0.08, the firm is deemed unprosperous.

$$\text{prosperity} = \frac{\text{equity}}{\text{liabilities}} \quad (21)$$

Out of a total of 2,478 enterprises, 102 are classified as non-prosperous, while 2,376 are deemed prosperous based on prosperity calculations. We used these 2,478 enterprises because we could identify their business activity in both 2022 and 2023. Finally, a total of 204 firms, including 102 non-prosperous and 102 randomly selected prosperous enterprises, were used to develop the classification equation in the SPSS software.

### 3. Results

Firstly, to evaluate how selected financial indicators evolved over time, median values of key ratios related to activity, liquidity, profitability, and indebtedness were calculated for each year between 2018 and 2023. The Friedman test was applied to determine whether time had a statistically significant impact on the indicators' values. The following Table 2 presents the calculated medians alongside the computed median values of financial analysis ratios for NACE C with the outcomes of the Friedman test. Upon comparing the estimated  $p$ -values with the significance threshold  $\alpha$  for all indicators, the null hypothesis  $H_0$  is rejected, since the  $p$ -values for all indicators were below 0.001, hence supporting the acceptance of the alternative hypothesis  $H_1$ . Upon doing the test, we concluded that a minimum of two distributions vary in position for each indicator, indicating that time influences the value of all selected indicators.

Secondly, we ran the procedures to create a prediction model for SMEs in the manufacturing sector. The assumptions related to the application of discriminant analysis were validated. These represent the disparities in the mean values of the independent variables and the concordance of the covariance matrices. Upon comparing the  $p$ -values from Table 3 with the significance threshold of 0.05, the subsequent conclusion was reached. The null hypothesis is rejected, and the alternative hypothesis is accepted. This outcome delineates the varying mean values of the independent variables and confirms the premise of their adequate discriminatory ability.

In developing a predictive model, it is essential to utilise Box's test for the equality of covariance matrices. Upon comparing the  $p$ -value from Table 4 with the significance level of 0.05, the conclusion drawn is that the null hypothesis is rejected and the alternative hypothesis is accepted, indicating that the covariance matrices of the independent variables between the group of prosperous enterprises and the group of non-prosperous enterprises are not identical. Consequently, two distinct covariance matrices were employed in subsequent calculations.

Table 5 presents the computed values of the variance inflation factor (VIF) for each independent variable. All VIF values are below 2.5, indicating an absence of substantial linear dependency among the explanatory variables. This computation demonstrates the absence of multicollinearity.

*Table 2: Values of calculated indicators and result of analysing the impact of time on indicators*

|                               | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | Impact of time |
|-------------------------------|--------|--------|--------|--------|--------|--------|----------------|
| <b>Activity</b>               |        |        |        |        |        |        |                |
| Assets turnover               | 1.56   | 1.55   | 1.43   | 1.45   | 1.60   | 1.55   | < 0.001        |
| Assets turnover period        | 233.76 | 234.79 | 256.10 | 250.87 | 228.30 | 235.48 |                |
| Inventory turnover            | 7.41   | 7.32   | 6.72   | 6.06   | 6.74   | 7.00   |                |
| Inventory turnover period     | 49.27  | 49.82  | 54.33  | 60.22  | 54.14  | 52.11  |                |
| Collection period ratio       | 43.10  | 39.34  | 39.36  | 42.13  | 39.28  | 38.56  |                |
| Credit period ratio           | 52.41  | 48.52  | 48.52  | 51.79  | 47.57  | 43.89  |                |
| <b>Liquidity</b>              |        |        |        |        |        |        |                |
| Cash ratio                    | 0.13   | 0.15   | 0.20   | 0.18   | 0.16   | 0.19   | < 0.001        |
| Quick ratio                   | 0.80   | 0.81   | 0.89   | 0.87   | 0.84   | 0.95   |                |
| Current ratio                 | 1.24   | 1.26   | 1.36   | 1.38   | 1.39   | 1.46   |                |
| <b>Profitability</b>          |        |        |        |        |        |        |                |
| Return on equity              | 7.57%  | 6.61%  | 6.34%  | 8.42%  | 8.82%  | 9.24%  | < 0.001        |
| Return on assets              | 2.59%  | 2.38%  | 2.58%  | 3.30%  | 3.38%  | 3.60%  |                |
| Return on sales               | 1.68%  | 1.54%  | 1.80%  | 2.14%  | 2.16%  | 2.32%  |                |
| <b>Indebtedness</b>           |        |        |        |        |        |        |                |
| Total indebtedness ratio      | 64.13% | 62.75% | 60.82% | 60.90% | 60.30% | 58.48% | < 0.001        |
| Self-financing ratio          | 35.87% | 37.25% | 39.18% | 39.10% | 39.70% | 41.52% |                |
| Long-term indebtedness ratio  | 1.82%  | 2.01%  | 1.90%  | 1.91%  | 1.77%  | 1.79%  |                |
| Short-term indebtedness ratio | 32.76% | 30.71% | 28.66% | 30.01% | 30.60% | 27.77% |                |
| Financial leverage ratio      | 2.42   | 2.36   | 2.24   | 2.31   | 2.31   | 2.19   |                |
| Commercial insolvency ratio   | 0.86   | 0.86   | 0.85   | 0.86   | 0.87   | 0.79   |                |
| Total insolvency ratio        | 1.35   | 1.41   | 1.40   | 1.36   | 1.38   | 1.23   |                |
| Interest coverage ratio       | 3.39   | 3.14   | 2.91   | 4.47   | 4.62   | 3.43   |                |

*Source: own elaboration based on calculations and output from IBM SPSS*

*Table 3: Tests of equality of group means*

| Indicator                | Wilks' lambda | F-statistics | df1 | df2 | p-value |
|--------------------------|---------------|--------------|-----|-----|---------|
| Self-financing ratio     | 0.637         | 114.888      | 1   | 202 | < 0.001 |
| Financial leverage ratio | 0.945         | 11.832       | 1   | 202 | 0.001   |
| Insolvency ratio         | 0.953         | 9.997        | 1   | 202 | 0.002   |
| Current ratio            | 0.866         | 31.324       | 1   | 202 | < 0.001 |
| Return on equity         | 0.864         | 31.831       | 1   | 202 | < 0.001 |
| Credit period ratio      | 0.890         | 24.904       | 1   | 202 | < 0.001 |

*Source: own elaboration based on output from IBM SPSS*

*Table 4: Box's test of equality of covariance matrices*

|         |         |            |
|---------|---------|------------|
| Box's M |         | 1,186.911  |
| F       | Approx. | 54.733     |
|         | df1     | 21         |
|         | df2     | 150,077.05 |
|         | p-value | < 0.001    |

*Source: own elaboration based on output from IBM SPSS*

*Table 5: Variance inflation factor*

| Financial indicator      | VIF   |
|--------------------------|-------|
| Self-financing ratio     | 1.489 |
| Financial leverage ratio | 1.070 |
| Insolvency ratio         | 1.050 |
| Current ratio            | 1.401 |
| Return on equity         | 1.038 |

|                     |       |
|---------------------|-------|
| Credit period ratio | 1.168 |
|---------------------|-------|

Source: own elaboration based on output from IBM SPSS

Table 6 presents two values: the eigenvalue and the canonical correlation value of the established classification function from the canonical discriminant analysis. The number 0.744 signifies that the canonical discriminant function can effectively differentiate between prosperous and unprosperous firms with a high degree of accuracy.

Table 6: Canonical correlation of the discriminant function

| Function | Eigenvalue | Canonical correlation |
|----------|------------|-----------------------|
| 1        | 1.243      | 0.744                 |

Source: own elaboration based on output from IBM SPSS

Table 7 presents the value of Wilks' lambda, utilised to assess the relevance of the established discriminant function. Upon comparing the p-value to the significance level of 0.05, the null hypothesis is rejected, and the alternative hypothesis is accepted. This outcome indicates that the established canonical discriminant function is statistically significant.

Table 7: Significance of the canonical discriminant function

| Test of functions | Wilks' lambda | Chi-square | df | p-value |
|-------------------|---------------|------------|----|---------|
| 1                 | 0.446         | 160.743    | 6  | < 0.001 |

Source: own elaboration based on output from IBM SPSS

Table 8 facilitates the comparison of standardised coefficient values for individual variables. The self-financing indicator demonstrates the most discriminating capacity.

Table 8: Standardized canonical discriminant function coefficients

| Financial indicator      | Value of standardized coefficients |
|--------------------------|------------------------------------|
| Self-financing ratio     | 0.750                              |
| Financial leverage ratio | 0.357                              |
| Insolvency ratio         | -0.333                             |
| Current ratio            | 0.212                              |
| Return on equity         | 0.590                              |
| Credit period ratio      | -0.203                             |

Source: own elaboration based on output from IBM SPSS

Table 9 presents the values of the unstandardised coefficients for the canonical discriminant function.

Table 9: Canonical discriminant function coefficients

| Financial indicator      | Value of unstandardized coefficients |
|--------------------------|--------------------------------------|
| Self-financing ratio     | 1.184                                |
| Financial leverage ratio | 0.034                                |
| Insolvency ratio         | -0.021                               |
| Current ratio            | 0.099                                |
| Return on equity         | 0.976                                |
| Credit period ratio      | -0.003                               |
| Constant                 | 0.158                                |

Source: own elaboration based on output from IBM SPSS

Utilising the values of unstandardised coefficients, the subsequent model was formulated:

$$\begin{aligned}
 y = & 0.158 + 1.184 \cdot \text{Self financing ratio} + 0.034 \\
 & \cdot \text{Financial leverage ratio} - 0.021 \cdot \text{Insolvency ratio} \\
 & + 0.099 \cdot \text{Current ratio} + 0.976 \cdot \text{Return on equity} \\
 & - 0.003 \cdot \text{Credit period ratio}
 \end{aligned}
 \tag{22}$$

Table 10 presents centroids for distinct groupings of businesses. The study only concentrated on contrasting the computed sign of the Z-score with the sign of the centroid. A positive Z-score indicates that the firm might be categorised as prosperous. If the Z-score is negative, the enterprise is deemed unprosperous.

The model's classification capability was evaluated using the identical dataset (sample of business entities) on which it was developed. Table 11 facilitates the comparison between actual and expected classifications, enabling the precise determination of the number of correctly

*Table 10: Functions at group centroids*

|                                    | Centroids |
|------------------------------------|-----------|
| 0 (prosperous business entity)     | 1.109     |
| 1 (non-prosperous business entity) | -1.109    |

*Source: own elaboration based on output from IBM SPSS*

categorised business enterprises. In the analysed data sample, 186 firms were accurately categorised out of a total of 204 enterprises. The model's total accuracy is 91.2% for accurately predicted situations. 96.1% of firms were accurately categorised as affluent, while 86.3% were categorised as unprosperous.

*Table 11: Validation on the sample of enterprises*

| Classification results |       |                | Predicted group membership |                |       |
|------------------------|-------|----------------|----------------------------|----------------|-------|
|                        |       |                | prosperous                 | non-prosperous | Total |
| Original               | Count | prosperous     | 98                         | 4              | 102   |
|                        |       | non-prosperous | 14                         | 88             | 102   |
|                        | %     | prosperous     | 96.1%                      | 3.9%           | 100%  |
|                        |       | non-prosperous | 13.7%                      | 86.3%          | 100%  |

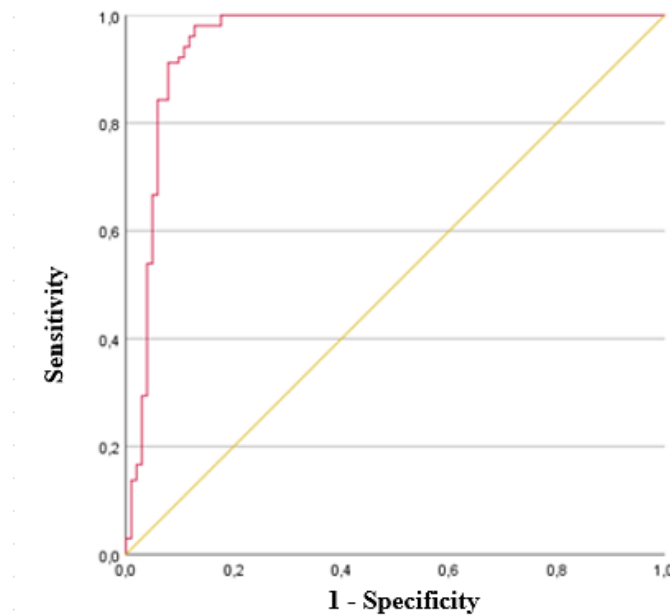
91.2% of original grouped cases correctly classified.

*Source: own elaboration based on output from IBM SPSS*

The primary instruments for evaluating model quality and comparing models are the classification table and the ROC curve, specifically the area under this curve (AUC). The AUC value assesses the model's prediction capability. If the AUC value is about 0.5, the model's predictive capability is negligible or feeble. If the value lies within the range of 0.7 to 0.8, the model's quality is considered high. If the interval is 0.8 to 0.9, the model quality is excellent. In this scenario, a score over 0.9 indicates outstanding model quality (Durica et al., 2023).

Figure 1 illustrates the classification ability of the prediction model for the post-COVID era, represented by the ROC curve derived from data pertaining to small and medium-sized enterprises within a NACE C sample. The area under the curve attains a value of 0.952. This rating reflects the model's excellent excellence.

*Figure 1: ROC curve*



*Source: own elaboration based on output from IBM SPSS*

#### **4. Discussion**

The prediction of corporate bankruptcy and economic distress is of interest to several stakeholders, including business entities, financial institutions, investors, regulatory agencies, auditors, and scholars. Diverse statistical and artificial intelligence techniques have been developed to yield more precise forecasts (Zhao et al., 2024a). Knowledge of impending bankruptcy is essential for financial institutions, managerial decision-makers, and governmental authorities. Given that bankruptcy prediction is a well-studied subject, several novel methodologies have been consistently introduced (Gnip et al., 2025). Increasing indebtedness can pose a challenging financial predicament for businesses, resulting in default and an incapacity to fulfil their impending liabilities (Gajdosikova et al., 2023).

Valaskova et al. (2023) create a model that predicts bankruptcy utilising financial data from 20,693 business entities across various sectors in the Visegrad group nations during the post-pandemic period (2020-2021) and find key predictors of bankruptcy. The authors employed multiple discriminant analysis to construct separate prediction models for each Visegrad Group nation, as well as a comprehensive model for the whole Visegrad Group. Conventional predictive methods, such as logistic regression and discriminant analysis, are limited by their incapacity to manage complicated and high-dimensional data. Recent advancements in machine learning, namely autonomous learning classifiers, provide a promising alternative (Sabek et al., 2024). Corporate bankruptcies frequently result in significant repercussions for all stakeholders, including financial investors forfeiting their capital and employees being laid off. Traditional bankruptcy prediction models primarily concentrate on forecasting the occurrence of bankruptcy, neglecting the socio-economic ramifications of their predictions. Consequently, Radovanovic and Haas (2023) concentrate on integrating these opinions into the machine-learning (ML) modelling process to consider for various expenses associated with bankruptcy. Predictions of business defaults are utilised in several sectors throughout the economy. Numerous recent studies endeavour to predict company insolvency employing diverse machine learning methodologies. Noh (2023) examine bankruptcy prediction models, including logistic regression, k-nearest neighbour, decision tree, and random forest, for the period from 2012 to

2021. Charalambous et al. (2023) establish a framework to concurrently calculate the latent parameters inherent in structural-parametric models for bankruptcy prediction. Horvathova et al. (2023) create a dynamic bankruptcy prediction model utilising a rarely applied approach, specifically graph theoretical modelling. A dynamic model incorporating the causal relationship among financial variables was developed for the period 2015-2021. Kanasz et al. (2023) introduced an innovative bankruptcy prediction method with a shallow autoencoder ensemble optimised by a genetic algorithm. To far, most research has concentrated on generating forecasts utilising artificial intelligence models that are supplied just with accounting data or a mixture of accounting data and additional categories of information. Zhao et al. (2024b) propose novel corporate governance mechanisms that use relational information within corporations by using the networks of boards of directors and the notion of node embeddings, which include mapping extensive director networks to lower-dimensional spaces. The impact of these additional factors on overall predictive performance they evaluated by using data from UK firms listed on the London Stock Exchange. Predicting bankruptcy is essential for evaluating financial risks and facilitating informed decision-making for investors and regulatory authorities. With the advancement of machine learning techniques, there has been significant interest in bankruptcy prediction because to its ability to manage complex data patterns and enhance predictive accuracy (Mate et al., 2023). Assessing the bankruptcy risk of small and medium-sized firms (SMEs) is essential for informed loan decision-making. Current research in finance and AI predominantly focusses on either intra-risk or contagion risk of business entities, neglecting their interconnections and combinatorial consequences. Wei et al. (2024) for the first time examine both categories of risk and their combined impact on bankruptcy prediction. Authors propose an enterprise intra-risk encoder grounded in statistically significant enterprise risk indicators for intra-risk learning. They offer an enterprise contagion risk encoder utilising an enterprise knowledge graph for contagion risk embedding.

## **5. Conclusions**

The goal of this article was to assess the financial health of SMEs in Slovak manufacturing and to develop a predictive model that identifies financially distressed firms using key financial ratios. It examined the development of financial indicators related to activity, liquidity, profitability, and indebtedness over the period from 2018 to 2023. By applying statistical tools such as the Friedman test, the study confirmed that time had a statistically significant influence on the values of all selected financial indicators. Additionally, the research developed a predictive model through discriminant analysis using financial data from 2022 to forecast business prosperity in 2023. The model demonstrated high accuracy, correctly classifying 91.2% of firms, with a strong predictive quality indicated by an AUC value of 0.952.

Despite its strengths, the study encountered several limitations and barriers. One limitation was the scope of data, as the analysis included only those enterprises that operated continuously throughout the six-year period, excluding younger or more volatile firms whose financial trajectories might differ. Another constraint was the exclusive focus on the industrial sector (NACE C), which restricts the applicability of the findings to other sectors of the economy. Moreover, the classification model simplified firm prosperity into a binary outcome based solely on the equity-to-liabilities ratio, potentially overlooking more nuanced aspects of financial health. The model also did not account for broader macroeconomic variables such as inflation, interest rates, or international market influences, all of which may have a considerable impact on firm performance. The classification ability was tested based on training data; it did not use a test sample of enterprises. Additionally, given the dynamic economic environment

following the COVID-19 pandemic, the long-term reliability of the model may be subject to change.

To address these limitations and deepen the understanding of SME financial stability, future research could expand the scope to use a test sample of enterprises from manufacturing and then include multiple economic sectors for cross-sectoral comparison. Incorporating external macroeconomic indicators and qualitative variables, such as innovation capacity or managerial effectiveness, could enhance model robustness. Further, applying advanced machine learning methods may allow for more complex and flexible prediction models. Lastly, examining regional disparities and conducting longitudinal studies on firm survival could provide more comprehensive insights into the financial resilience of SMEs in Slovakia.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Acknowledgments:** This research was financially supported by the Slovak Research and Development Agency Grant VEGA 1/0494/24: Metamorphoses and causalities of indebtedness, liquidity and solvency of companies in the context of the global environment.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Act 513/1991 Coll—Slovak Commercial Code. Online. <https://www.slov-lex.sk/ezbierky/pravne-predpisy/SK/ZZ/1991/513/>
- Bugaj, M., Durana, P., Blazek, R., & Horak, J. (2023). Industry 4.0: Marvels in profitability in the transport sector. *Mathematics*, 11(17), 3647. <https://doi.org/10.3390/math11173647>
- Charalambous, C., Martzoukos, S. H., & Taoushianis, Z. (2023). A neuro-structural framework for bankruptcy prediction. *Quantitative Finance*, 23(10), 1445-1464. <https://doi.org/10.1080/14697688.2023.2230241>
- Chatterjee, S., Chaudhuri, R., & Vrontis, D. (2023b). Business hybrid offerings by manufacturing SMEs: Impact of servitization on internationalization of manufacturing SMEs. *International Marketing Review*, 40(4), 585-611. <https://doi.org/10.1108/IMR-10-2021-0298>
- Chatterjee, S., Chaudhuri, R., & Vrontis, D. (2021). Antecedents and consequence of social media marketing for strategic competitive advantage of small and medium enterprises: Mediating role of utilitarian and hedonic value. *Journal of Strategic Marketing*, 32(8), 1106-1125. <https://doi.org/10.1080/0965254X.2021.1954070>
- Chatterjee, S., Chaudhuri, R., Shah, M., & Maheshwari, P. (2022a). Big data driven innovation for sustaining SME supply chain operation in post COVID-19 scenario: Moderating role of SME technology leadership. *Computers & Industrial Engineering*, 168, 108058. <https://doi.org/10.1016/j.cie.2022.108058>
- Chatterjee, S., Chaudhuri, R., Vrontis, D., & Galati, A. (2023a). Influence of managerial practices, productivity, and change management process on organizational innovation capability of small and medium businesses. *European Business Review*, 35(5), 839-859. <https://doi.org/10.1108/EBR-02-2023-0049>
- Chatterjee, S., Chaudhuri, R., Vrontis, D., & Thrassou, A. (2022b). SME entrepreneurship and digitalization—the potentialities and moderating role of demographic factors. *Technological Forecasting and Social Change*, 179, 121648. <https://doi.org/10.1016/j.techfore.2022.121648>
- Chaudhuri, R., Chatterjee, S., Vrontis, D., & Chaudhuri, S. (2022). Innovation in SMEs, AI dynamism, and sustainability: The current situation and way forward. *Sustainability*, 14(19), 12760. <https://doi.org/10.3390/su141912760>
- Culkova, K., Tausova, M., Muchova, M., Domaracka, L. & Taus, P. (2018). Indebtedness in chosen industrial sectors with regard to economic development in the world. *Ekonomicky casopis*, 66(1), 28-42.

- Das, S., Hassan, M., & Pachoni, P. (2023). Measuring financial health and performance of the oil and natural gas companies in India. *Indian Journal of Economics and Development*, 19(4), 873-879. <https://doi.org/10.35716/IJED-22475>
- Durana, P., Blazek, R. & Kovalova, E. (2024). Sherlock Holmes between homogeneity tests: Detection power based on profitability ratios in the V4 region. *Stats*, 7(4), 1333-1353. <https://doi.org/10.3390/stats7040077>
- Durana, P., Kovalova, E., Blazek, R., & Bicanovska, K. (2025). Business efficiency: Insights from Visegrad four before, during, and after the COVID-19 pandemic. *Economies*, 13(2), 26. <https://doi.org/10.3390/economies13020026>
- Durica, M., Frnda, J., & Svabova, L. (2023). Artificial neural network and decision tree-based modelling of non-prosperity of companies. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 18(4), 1105-1131. <https://doi.org/10.24136/eq.2023.035>
- Gajdosikova, D., Valaskova, K., Klietstik, T., & Kovacova, M. (2023). Research on corporate indebtedness determinants: A case study of Visegrad group countries. *Mathematics*, 11(2), 299. <https://doi.org/10.3390/math11020299>
- Gnip, P., Kanasz, R., Zoricak, M., & Drotar, P. (2025). An experimental survey of imbalanced learning algorithms for bankruptcy prediction. *Artificial Intelligence Review*, 58(4), 104. <https://doi.org/10.1007/s10462-025-11107-y>
- Horvathova, J., Mokrisova, M., & Baca, M. (2023). Bankruptcy prediction for sustainability of businesses: the application of graph theoretical modeling. *Mathematics*, 11(24), 4966. <https://doi.org/10.3390/math11244966>
- Jencova, S., Miskufova, M., & Letkovsky, S. (2024). Is Logistic regression reliable in bankruptcy prediction?. *Journal of Management and Business: Research and Practice*, 16(1), 1-11. <https://journalmb.eu/JMB/article/view/89>
- Jencova, S., Vasanicova, P., Stefko, R., & Lukacova, M. (2021). Financial analysis and competitiveness of public universities of Slovakia in the context of financial management. *Polish Journal of Management Studies*, 24(2), 156-177. <https://doi.org/10.17512/pjms.2021.24.2.10>
- Jihadi, M., Vilantika, E., Hashemi, S. M., Arifin, Z., Bachtiar, Y. & Sholichah, F. (2021). The effect of liquidity, leverage, and profitability on firm value: Empirical evidence from Indonesia. *Journal of Asian Finance, Economics and Business*, 8(3), 423-431. <https://doi.org/10.13106/jafeb.2021.vol8.no3.0423>
- Kanasz, R., Gnip, P., Zoricak, M., & Drotar, P. (2023). Bankruptcy prediction using ensemble of autoencoders optimized by genetic algorithm. *PeerJ Computer Science*, 9, e1257. <https://doi.org/10.7717/peerj-cs.1257>
- Kumar, V., Thrikawala, S. & Acharya, S. (2022). Financial inclusion and bank profitability: Evidence from developed market. *Global Finance Journal*, 53, 100609. <https://doi.org/10.1016/j.gfj.2021.100609>
- Klietstik, T., Valaskova, K., Klietstikova, J., Kovacova, M., & Svabova, L., (2019). *Predikcia financneho zdravia podnikov tranzitivnych ekonomik*. University of Zilina in Zilina: EDIS.
- Mate, D., Raza, H., & Ahmad, I. (2023). Comparative analysis of machine learning models for bankruptcy prediction in the context of Pakistani companies. *Risks*, 11(10), 176. <https://doi.org/10.3390/risks11100176>
- Noh, S. H. (2023). Comparing the performance of corporate bankruptcy prediction models based on imbalanced financial data. *Sustainability*, 15(6), 4794. <https://doi.org/10.3390/su15064794>
- Pavlicko, M., Durica, M., & Mazanec, J. (2021). Ensemble model of the financial distress prediction in Visegrad group countries. *Mathematics*, 9(16), 1886. <https://doi.org/10.3390/math9161886>
- Podhorska, I., & Siekelova, A. (2020). Enterprises financial performance in a globalized world. *SHS Web of Conferences*, 74, 05018. <https://doi.org/10.1051/shsconf/20207405018>
- Radovanovic, J., & Haas, C. (2023). The evaluation of bankruptcy prediction models based on socio-economic costs. *Expert systems with applications*, 227, 120275. <https://doi.org/10.1016/j.eswa.2023.120275>
- Sabek, A., Horak, J., Musa, H., & Da Silva, A. F. (2024). Bankruptcy Prediction Using First-Order Autonomous Learning Multi-Model Classifier. *Statistika: Statistics & Economy Journal*, 104(4), 440-464. <https://doi.org/10.54694/stat.2024.30>
- Stangova, N. & Vighova, A. (2021). Company Liquidity as a reflection of receivables and payables management. *Entrepreneurship and Sustainability Issues*, 9(2), 238-254. [http://doi.org/10.9770/jesi.2021.9.2\(16\)](http://doi.org/10.9770/jesi.2021.9.2(16))
- SK NACE (2025). *NACE C Manufacturing*. <http://www.nace.sk/nace/c-sekcia-c-priemyselna-vyroba/>
- Valaskova, K., Gajdosikova, D., & Belas, J. (2023). Bankruptcy prediction in the post-pandemic period: A case study of Visegrad Group countries. *Oeconomia Copernicana*, 14(1), 253-293. <https://doi.org/10.24136/oc.2023.007>
- Valaskova, K., Klietstik, T. & Gajdosikova, D. (2021). Distinctive determinants of financial indebtedness: Evidence from Slovak and Czech enterprises. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 16(3), 639-659. <https://doi.org/10.24136/eq.2021.023>

*Evaluating financial stability and predictive modelling  
of SME prosperity in manufacturing*  
*Authors: Veronika Kusnierikova, Simona Vojtekova,  
Sheshadri Chatterjee*

- Wei, S., Lv, J., Guo, Y., Yang, Q., Chen, X., Zhao, Y. & Kou, G. (2024). Combining intra-risk and contagion risk for enterprise bankruptcy prediction using graph neural networks. *Information Sciences*, 659, 120081. <https://doi.org/10.1016/j.ins.2023.120081>
- Zhao, J., Ouenniche, J., & De Smedt, J. (2024a). Survey, classification and critical analysis of the literature on corporate bankruptcy and financial distress prediction. *Machine Learning with Applications*, 15, 100527. <https://doi.org/10.1016/j.mlwa.2024.100527>
- Zhao, J., Ouenniche, J., & De Smedt, J. (2024b). A complex network analysis approach to bankruptcy prediction using company relational information-based drivers. *Knowledge-Based Systems*, 300, 112234. <https://doi.org/10.1016/j.knosys.2024.112234>

## SUN POWERED SYSTEMS: EXPANDING EU GREEN INNOVATIONS UNDER THE AFRICAN SUN

Stanislav Zabochnik<sup>1,a,\*</sup> and John Branch<sup>2,3,b</sup>

<sup>1</sup>University of Zilina, Faculty of Operation and Economics of Transport and Communications,  
Department of Economics, Univerzitna 1, 010 26 Zilina, Slovakia

<sup>2</sup>Ross School of Business, University of Michigan, Clinical Associate Professor of Business  
Administration and Co-Director of Yaffe Digital Media Initiative, USA

<sup>3</sup>Center for Russian, East European, and Eurasian Studies & William Davidson Institute, University of  
Michigan, Faculty Associate and Research Fellow, USA

<sup>a</sup>stanislav.zabochnik@uniza.sk, <sup>b</sup>jdbranch@umich.edu

\*Corresponding author

**Cite as:** Zabochnik, S., Branch, J. (2025). *Sun Powered Systems: Expanding EU Green Innovations Under the African Sun*, *Ekonomicko-manazerske spektrum*, 19(1), 97-116.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.97-116](https://dx.doi.org/10.26552/ems.2025.1.97-116)

---

*Received: 21 February 2025; Received in revised form: 27 March 2025; Accepted: 25 May 2025; Available online: 30 June 2025*

### Abstract:

*Research background:* This paper addresses a significant challenge in the decarbonization efforts within the European Union, namely the continual environmental ambitions confronting a company competitiveness. Employing case study methodology widely utilized at the University of Michigan, the authors critically examine the challenges associated with the international expansion of innovative SMEs into remote markets of third countries.

*Purpose of the Article:* The first section provides an overview of the EU's environmental objectives and the legislative-regulatory framework governing corporate activities within the EU. It elucidates the specific challenges faced by Slovak firms in their internationalization efforts, emphasizing the necessity of technological innovation alongside institutional support mechanisms.

*Methods:* The study is based on a detailed case analysis of a Slovak start-up engaged in exporting solar-powered agricultural machinery to the Kenyan market. The primary objective is to identify the main obstacles and specifics encountered by small enterprises during export processes, explore viable solutions, and outline the critical measures necessary for successful market entry and expansion within African markets.

*Findings & Added Value:* The authors delineate the growth potential of African markets for innovative energy solutions developed by startups from the CEE region. They highlight the unique contextual challenges faced by these companies in the African environment and propose feasible strategies for market entry, specifically targeting Kenya. The findings contribute valuable insights for practitioners and researchers, and the study can also serve as an educational resource suitable for pedagogical purposes in master and PhD. studies.

**Keywords:** decarbonisation; competitiveness; export to Africa; case study

**JEL Classification:** F10; F13; F60

## 1. Introduction

*"Using my patents, I'm selling a tractor that can operate without diesel and heavy mechanisms."*

Robert Demko

In December 2022, Robert Demko<sup>1</sup>, the sole manager and owner of the start-up company SUN Powered System was returning to Slovakia from abroad. He moved his start-up forward in the field of innovative technologies based on photovoltaics with products such as photovoltaic panels, autonomous public lighting, autonomous lighting for large advertising areas, photovoltaic chargers for bicycles, and several energy-efficient solutions for companies. However, the latest product was different. He dedicated a lot of innovation efforts, CAPEX, and his patents to it. This product was presented at an important energy event in Brussels. The product had the potential to advance his small, innovative business a step further. These ambitions were confirmed by the response and interest of investors, along with the awards received in Brussels.

From a height of 5,000 feet, he looked at the green fields between Vienna and Bratislava while landing. Together with twenty other "green" businessmen, he was returning from the conference in Brussels on a special flight organized by the Slovak government. He was there at the invitation of the Government Office of the Slovak Republic, as he had been for events in Amsterdam and Rome several times. As the sole owner of his innovative company, he presented his revolutionary patent in the field of environmentally friendly agriculture: a Solar Arm - an autonomous arm using photovoltaic drive (Appendix A) intended for small and medium farmers growing agricultural crops. Solutions based on decarbonization and sustainability principles were at the centre of Brussels' priorities, as the ultimate goal was to make the EU a leader in the field of green technologies by 2030. Today, the response from entrepreneurs was excellent.

But Robert's mind was elsewhere. In four weeks, he was scheduled to attend a meeting with H.E. the President of the Slovak Republic at the Slovak Embassy in Nairobi, where he was to present his product for the local market and decide on the specific mode in which he would be ready to expand his product into the Kenyan market. His CEE firm had some form of institutional support (government) for expansion into the Kenyan market. However, he faced competition from exporters and innovators from countries such as the Netherlands, Germany, and France, which have robust institutional support for entrepreneurs in foreign markets built up over centuries. This investment forum would open the door to unique foreign trade opportunities, but the strategy to enter the Kenyan market had to be decided now. The event under the auspices of the president held significant weight due to strong political support in developing countries; such an opportunity is rare in African destinations, even for medium-sized and large Slovak companies. It was a great opportunity outside the oversaturated European market, but it came with significant risks and potential failures. Robert was a technician—an excellent innovator—but not yet an experienced businessman. If he made the wrong decision, he would not only lose the opportunity in the foreign market but also risk the loss of time and capital, both crucial for an innovative start-up. This decision was all the more difficult.

---

<sup>1</sup> Ing. Robert Demko is a real character, a Slovak entrepreneur, innovator, and limited liability company owner (s.r.o.) SUN Powered Systems (detailed info here: <https://sunpoweredsystems.sk/>). This case study is based on the real business problem of the company.

## **2. Company facts and decarbonization trends**

### **2.1. Scene 1: Decarbonization efforts and competitiveness**

Since the Stern review on the economics of climate changes in 2006 (Stern, 2006), the environmental ambitions of the EU have been permanently strengthening as a top priority. The European Commission launched the energy union project in 2014 (2015 in force), focusing primarily on energy security, energy efficiency, decarbonization (renewable energy sources and emission allowances system), and not least, research, innovations, and competitiveness of the “greener” EU producers. There was a deliberate push to increase the share of renewable energy sources in the final energy consumption mix (Nagaj et al., 2024; Fu et al., 2024). This project was of great importance; therefore, Maros Sefcovic as a vice-chairman of the European Commission, was responsible for its implementation. Since decarbonization and investments into renewable sources are challenging industrial producers, particularly exporters, the European Commission emphasized business roles and competitiveness within the “green revolution.” In 2016, during the key opening speeches, Maros Sefcovic stated:

*„We have a historic opportunity to look at all initiatives together: our renewables legislation, our energy efficiency legislation, our GHG-emissions legislation, our integrated research, innovation and competitiveness strategy... They all interact with each other, so we should and will be coherent. Finally, the transition to a low-carbon society means that we will have to further mobilize other actors, such as businesses helping them to become true enablers of the EU's sustainable energy and climate policies.“*

Since then, the European Green Deal was approved in 2020, and the Fit For 55 package was publicly introduced in July 2021. This projects dramatically increased the engagement of renewable energy sources and decarbonization of the EU society till 2050. One of the key approaches that can take a society closer to achieving net-zero emissions is the extensive implementation of sustainable energy sources such as PV and CSP (Baur et al., 2024) and photovoltaic modules are a vital source of decarbonization solutions (Nazari et al., 2023). The Russian invasion of Ukraine and the subsequent energy crisis further intensified the need for a greener, energy-self-sufficient Europe. The topic of energy and industry decarbonization thus becomes a key topic for European industry and its industrial exports (Cerna et al., 2022), which the EU has dominated for decades. A big challenge in the EU is compliance with “green” ambitions and industrial competitiveness (living standards driven by businesses). The energy costs of the EU producers, partially to the “green energy revolution,” were considerably higher than in the USA or China. The negative externalities of decarbonization are noticeable primarily for industrial production and export companies. According to several authors, energy costs become a critical determinant of the competitiveness of selected EU industrial exporters (Cerna et al., 2022; Faiella and Mistretta, 2022), especially relevant for energy-intensive industries in the CEE region (Balaz and Bayer, 2019). On the other hand, due to “carbon leakage,” the EU has had to engage other countries to fight global climate change via active and ambitious sustainability goals. At the international level, African countries have huge potential for the decarbonization objectives of the EU (Pinto et al., 2024; Agyekum, 2024). During an official visit to Africa in 2015, Maros Sefcovic stated:

*„The project is at the heart of the European Union's political agenda but it is outwards looking, involving our partners around the world. As you know, in a globalized economy, energy has no borders. What happens in one part of the world has a great impact on others. When it comes to climate action - that is all the more true!“*

## **2.2. Scene 2: Challenges of the Slovak exporters**

After the economic reforms of the right-wing government of Mikulas Dzurinda in 1998, the Slovak economy received a massive volume of FDI inflows. Thanks to these, it became one of the most open economies in the world. Multinational companies used a cheap and educated labour force, high labour productivity, and exported the goods produced here to the entire EU common market. The Slovak economy's initial advantage proved insufficient for higher economic growth after 2014. Greater involvement of Slovak small and medium-sized companies in exports was absent. The ten largest export companies (almost exclusively owned by foreign shareholders) accounted for up to 40% of Slovak exports. This was in contrast to the healthy share and critical role of small and medium-sized enterprises (in the US, small enterprises make up 44% of the US GDP) in creating GDP (U.S. Small Business Administration Office of Advocacy, 2019).

The responsible institutions identified as one of the barriers to the export of these smaller Slovak companies the insufficient presence in foreign markets of third countries, where they exported only the minimum, and the government programs until 2020 were largely unsuccessful (Valaskova et al., 2022). To stimulate domestic exporters, the government triggered support schemes of Eximbanka (financing of small businesses in foreign markets), SARIO (support for the development of investments and trade), and support from Slovak embassies abroad (economic diplomacy services). These schemes were established specifically to support them. One of the critical tasks of Slovak companies was a higher rate of innovation, as investments in R&D were at a shallow level, and the rate of innovativeness of Slovak companies was among the lowest in the EU. The most deficient item in the Slovak foreign trade statistics is the category of fees for intellectual property rights, where companies established in the Slovak Republic must import a significantly larger volume of patents and innovative technologies than they can place on foreign markets.

## **2.3. Product Solar Arm**

Even in 2023, SUN Powered Systems operated as a start-up in innovative technologies and basic and advanced products in photovoltaic devices, autonomous devices, and robotics. It had a single owner, and its key products included photovoltaic panels, autonomous public lighting, autonomous lighting for large advertising areas, photovoltaic chargers for bicycles, and several energy-efficient solutions for companies. The company benefited from extremely innovative products that combine elements of photovoltaics and robotics (autonomous). The company was established and has a successful application in the Slovak market due to a difficult environment – marked by extremely demanding regulation in energy consumption, energy savings, and support of renewable energy sources. This boom, especially since 2015, enabled the company's founder to react with his inventions, which he had patented in Slovakia and the EU (currently ten patents). The company's primary goal was to provide innovative, ecological products that would positively impact society in Slovakia and abroad. Thanks to several successfully commercialized patents, the company's turnover had grown permanently since 2018, but in 2022 it reached 1 million €. The company had several activities abroad, but there are no major orders from foreign markets (except the Czech Republic) at present. Currently, the CEO was negotiating expansion on the Kenyan market, the market of the Dominican Republic. The company had only a few smaller competitors in common products (photovoltaics, public lighting, advertising lighting), as larger companies do not deal with such a narrow-profile segment. However, the company's pilot product faced no direct competition, as it embodies its founder's innovativeness.

The company's strategic asset was the constantly innovative Solar Arm product. It is an autonomous arm (Appendix A,B) for a photovoltaic drive. It was produced in two varieties – 12 meters and 18 meters long, and the programmed control panel manages the land in a circular, solar-powered layout. The device is very ecological (it does not use any fossil fuels and is not dependent on their supply, only the sun's energy), sustainable, and energetically autonomous (off the grid). It was designed to perform the function of a small tractor in agribusiness production. The arm was thus fully capable of plowing the soil without human effort, autonomously sowing or planting agricultural products even deep into the soil (planting), and automated irrigation in a defined area (irrigation).

The system used an AC asynchronous motor with a rotational speed of 1500 rounds per minute and a power of 750 W for motion. It can be equipped with commercially available solar modules of small size, as well as LiFePo batteries and frequency regulators. The advantage of the device is its optimized use of photovoltaic energy, so that only approximately 50% of the energy produced by the sun during operation is consumed by the machine. According to the inventor's design, the remaining energy is stored in accumulators. It can be used for other purposes: power for further irrigation, electricity for the water pump, and charging other devices, including smartphones or simple domestic appliances (lamps, etc.). This creates a significant advantage of a universally usable battery in agribusiness, especially in remote areas where accessibility to cities and fossil resources is more problematic. The original plan for dynamic electricity consumption (a conception of "prosumer") in the EU's decentralized electricity system motivated Robert Demko to develop a kind of "Tesla tractor" and similar agricultural production, where surplus energy would be widely usable. Similarly, to what more western European households do, when the price of electricity is high, discharging their battery electric vehicles into the domestic electrification network at specific time slots for a financial reward.

However, the innovativeness of this product for agribusiness persists beyond the energy parameters. The Solar arm addresses a fundamental problem for many farmers: the high presence of pesticides, herbicides, and insecticides. The way the solar component is utilized and the well-designed technology make it possible to grow organic food without the necessary use of these unwanted synthetic substances, partly due to the lightweight (significantly lower compared to a small tractor and the destruction/suppression of arable land by tires). In essence, the device produces organic food in a very gentle way toward the soil. The device has zero operating costs; the product is fresh and healthy vegetables. That is why start-up farmers and micro and small-sized farms turn to it. It is an enormous advantage, especially for depleted soil types and areas with problematic irrigation. With heavy machinery, the soil becomes drained and damaged. Otherwise, chemical treatments are necessary.

Another fundamental advantage is the maintenance of moisture - rammed earth does not retain water, and nutrients are washed away from it. The soil has the appearance of a soaked sponge with significantly gentler tillage (with lower weight); it maintains its natural biodiversity and bacteria. At the same time, the Solar Arm mechanically but gently removes weeds. In the EU, the device aroused a positive response, especially from German farmers, being the leader of the EU's "decarbonization transformation," not only minimizes the consumption of fossil fuels but also intensively tackles the release of CO<sub>2</sub> in agriculture more intensively. It may sound unbelievable from outside the EU, but German farmers who avoid disturbing the soil by plowing at greater depths are even specially rewarded (subsidized) for a gentle and eco-friendly way of agricultural production, resulting in lower levels of CO<sub>2</sub> emissions, after demonstrating this effect. Solar Arm does not disturb the root systems of plants

in the soil and CO<sub>2</sub>-impermeable layers, as is the case with heavy machinery used in agriculture, by gently plowing the soil.

### **3. Kenyan market and decarbonization plans in agrobusiness**

#### **3.1. Market potential in Kenya**

The Kenyan economy is one of the more advanced African economies. The average life expectancy is about the same as India. Promising potential for business opportunities is indicated by economic growth, which in the pre-pandemic period ranged from 4 to 5% per year, and the standard of living expanded dynamically. The main export partners in the top five include the USA, the Netherlands or the UK. Kenyan companies are the largest exporters of coffee, tea, cut flowers (the top exporter in the world) and other agricultural products and mineral raw materials. A strategic port for export to the Kenyan market is Mombasa on the east coast of Kenya and the terminal port of Lamu.

The population of this country is approximately 55 million, but according to the World Bank's predictions, up to 92 million people are expected to live here by 2050. The youth population will more than double (World Bank Group, 2025), so there is an urgent need for solutions to increase agricultural productivity while also considering climate goals and minimizing the consumption of fossil resources. Indeed, Kenya, like some developed market economies, has ambitious goals in renewable energy sources as a path to decarbonization. Based on research results of Odhiambo (2022), it can be concluded that the current burgeoning FDI inflows that Kenya has attracted in recent years are largely driven by strong economic growth and prudent macroeconomic policies that the country has been pursuing in recent decades.

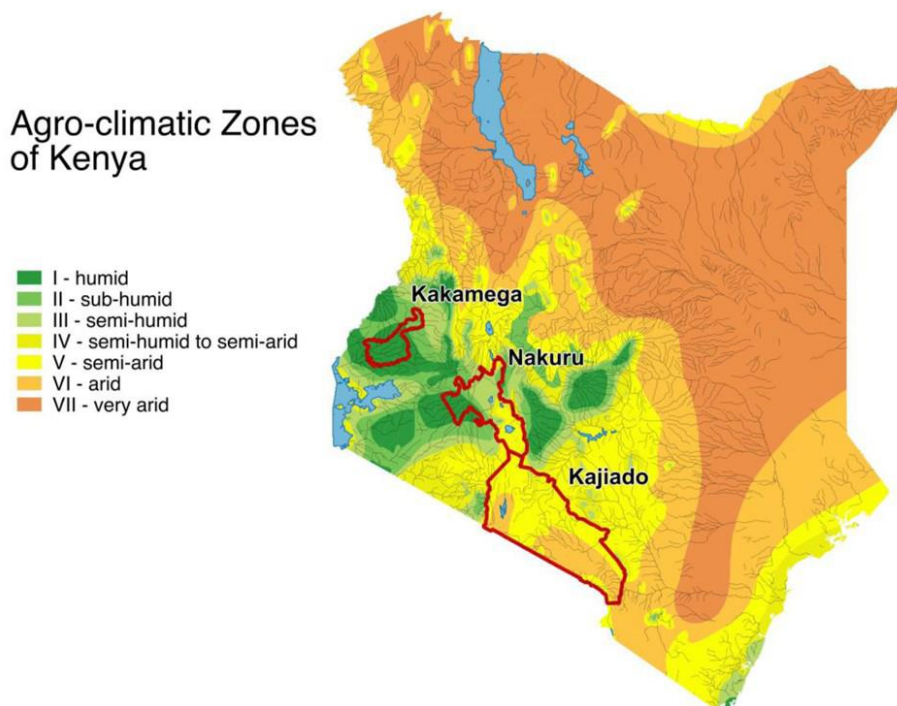
By African standards, the living standards here are relatively high — indicating potential for selling European products. Companies consider Kenya very promising also because, if they manage to expand into this market, they can leverage the duty-free expansion to the entire East African region (AfCFTA, EAC). However, the risk to the local market is high due to corruption. Some unexpected advantages are the range of telecommunication services and 5G coverage comparable to European countries, an unexploited market, and a relatively less competitive environment. According to some authors (Andersen et al., 2022), there appears to be overall quite strong business incentives to go circular among Kenyan companies, although these incentives are not necessarily realized by the companies — a factor that could be exploited in policymaking. The specifics of the Kenyan economy also include the energy mix, as most electricity is produced from renewable sources, with geothermal energy playing a vital role. However, energy consumption per capita needs to increase, limiting the growth of living standards in the area.

#### **3.2. Business opportunities in Kenyan agriculture**

*“Today more than ever, farmers in Kenya face profound changes – from climate change, labour shortages and global pandemics such as COVID-19, to an explosive rise in digital technologies, shifting diets and rigorous global and national food safety standards.”*

John Preissing, the Deputy Director – FAO Investment Centre

Figure 1: Agro-climatic zones of Kenya



Source: Chepkoech et al. (2018)

Agriculture constitutes a significant economic sector for all Sub-Saharan African countries, especially Kenya, where it engages over 80% of the population (Nduru, 2011). In Kenya, agriculture is extraordinarily valuable. Agriculture represents over 50 % of the country's GDP, 60 % of employment, and 65 % of exports (FAO, 2022). The water problem during the dry season characterizes and negatively determines Kenyan agribusiness. After heavy rains, water rapidly washes away nutrients from the soil. Water usually flows away the topsoil. In local agriculture, there is also a problem with the weathering of topsoil during strong winds. Kenya's high-rainfall areas comprise about 10% of Kenya's arable land and produce 70% of its national commercial agricultural output. Farmers in semi-arid regions contribute approximately 20% of the production, while the arid regions account for the remaining 10%. Productivity needs to increase in all areas due to poor incentives and underdeveloped supporting infrastructure and institutions (International Trade Administration, 2022). On the other hand, advanced technologies can help transform Kenya's agricultural sector, improve productivity, and enable the country to make significant progress toward achieving food security (Strathmore University and Microsoft, 2021). The sector employs approximately 40 % of the total population, with 73 % of farmers being small-scale producers in rural areas (Kenya Agricultural Research Institute, 2022).

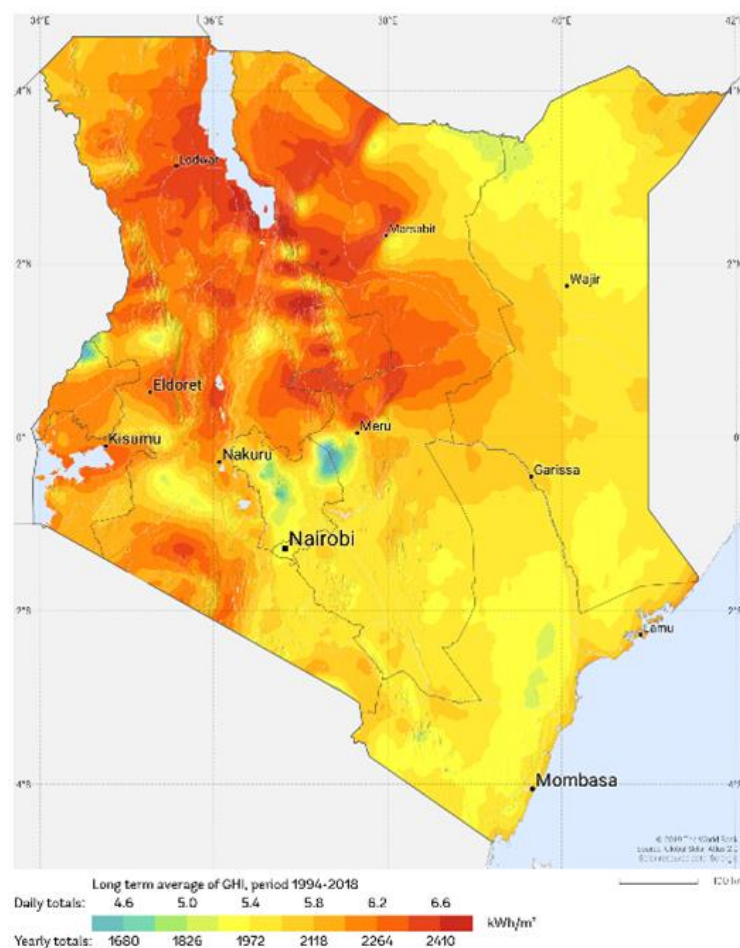
### 3.3. Support of the sustainability and smart solutions

Decarbonization strategies have been proven to be successful in the case of developed countries (Anser et al., 2024). Though, Kenyan agriculture has its own specificities. It is mostly made up of small and medium-sized farmers, despite being a crucial part of Kenya's GDP. These small farmers have only 0.2 to 3 hectares of land (Kenya Agricultural Research Institute, 2022). The fundamental problem of Kenyan agriculture is the obsolescence of production technologies (The Slovak Embassy in Nairobi, Kenya, 2022).

In addition to the mentioned problem with irrigation and pesticides, infrastructure is another challenge. A major problem is the condition of Kenya's rural roads, which make it impossible for Kenyan farmers to procure inputs for agricultural production without difficulties and, in particular, to commercialize their outputs. The government has taken several steps in this area to enable better marketing of the agricultural output.

Another challenge for the Kenyan economy and agriculture is the issue of sustainability and the necessary decarbonization. UN Sustainable development goals and Kenya Vision 2030 aim to make Kenya a newly industrialized, middle-income country with access to reliable, affordable, and sustainable energy (Ndung'u et al., 2011). Most of Kenya's installed electricity production capacity comes from green renewable sources. On the other hand, up to a quarter of the Kenyan population (primarily concentrated in the agricultural sector) lacks access to electricity. The Kenyan government supports diversification within the energy mix, especially if the photovoltaic potential remains to be fully exploited. The potential for producing electricity from panels is vast, since there are 2,525 hours of sunlight per year (World Bank Group, 2023) (compared to about 1,100 hours in central Europe).

Figure 2: Photovoltaic potential in Kenya



Source: World Bank Group (2023)

International trade is a valuable mechanism that saves time and process efficiency, as Kenyan farmers do not have to wait for "green solutions" in agribusiness to develop themselves but can import such products from abroad and benefit from them within a short time horizon. Several international initiatives and key projects, for example, the potential of photovoltaic

sources—as outlined in Vision 2030, represents the country's development program until 2030. Agriculture, infrastructure, and trade are the most important sectors. The new Value Added Tax legislation from 2013 discusses the business potential of photovoltaics in the region (import). The VAT Amendment Act 2014 and the Finance Act 2018 enabled the Kenyan government to remove import duty and implement zero-rated VAT for renewable energy equipment and accessories (USAID, 2019). Strong UK exporters have already contributed to achieving sustainability and decarbonization goals via tree planting by smallholder farmers and CO<sub>2</sub> capture (International Trade Administration, 2022). A significant increase in LED lamps across the countryside has already demonstrated the huge market potential (Wagner et al., 2021). The experience of British investors in Kenyan agribusiness indicates that Kenya is progressing toward adopting climate-smart practices in the fight against climate change. However, climate-smart technology requires substantial financing. In August 2021, about 35,000 farmers joined the Drylands Development Programme, which works with farmers to encourage the production of annual crops between or under trees—using a technique called agroforestry—and has supported them by introducing new technologies and improved farming practices to help maintain soil health (British International Investment, 2021).

### **3.4. A product potential for the Kenyan farmer**

Solar Arm represents a promising potential in developing micro, small, and medium farmers in Kenya. The product solves the fundamental problems of the Kenyan farmer, such as productivity, soil loosening, irrigation, automated planting, and a fundamental reduction in the need for pesticides and herbicides. A secondary benefit is battery availability. Depending on the arm size (12 or 18 meters) and the capacity of the accumulator, the initial investment is between €18,000 and €30,000. Robert's presentation to farmers regarding the stable sale of manufactured products to African farmers had a very good response and potential. At a simulated price of agricultural produce at \$1 per kilogram of organic vegetables, it is possible to grow 1 ton of vegetables per year on one agricultural cycle. Ten cycles would produce 10 tons per year. A maximum of 20 cycles per year can be farmed with one machine. The return on investment for the device at a price of €1 per kg is within five years, not including the secondary electricity used from the accumulators. Other benefits include the irrigation system supported by this device (using electricity for this purpose) and the reduction of fertilizer consumption. However, it is necessary to account for zero environmental impact, carbon emissions, and unconsumed fossil fuels (imported) when considering the benefits of the device. Additionally, the device emits less CO<sub>2</sub> than heavy machinery used in agriculture.

## **4. Managerial decision – shaping factors**

### **4.1. Sustainable agrobusiness in Kenya – open questions and threats**

Based on the success of the European market, Robert was already convinced that the product is competitive, ecological, sustainable, and, on the part of the agro-entrepreneur, able to increase productivity and energy self-sufficiency (autonomy). However, the financing aspect combined with the expansion method, crucial for success in the Kenyan market, needed to be revised. The small agribusiness had a minimal or no liquidity, and therefore, the issue of financing this decarbonization product was directed toward the supplier.

The second topic, which has the fundamental potential to influence the success or failure of a small Slovak entrepreneur in the African market, was the range of differences in the local environment. Robert was worried about the differences in the soil. In Slovakia alone, there are

approximately 12 different soil types, based on which he adapted various product modifications in a "custom-made" style for customers, since the soil may have a more clayey character or be more compact. There was also a question mark regarding the rainy season in Kenya, with high variability in total rainfall across different regions.

As the map of soil fertility and climatic conditions shows, these regions are relatively far from the coast. This presents a potential threat of higher transport costs and the physical unavailability of customers. Commercially, it primarily represented the risk that the equipment might malfunction or that replacement parts would need to be purchased. The smallholder farmers would have to travel tens of kilometres to buy an alternative. However, Robert was confident that sophisticated yet simple solutions, based on standardized components, had already been used during product development. In case of an unexpected failure or damage to a part of the equipment, it is necessary to obtain a spare part from any major city.

Another challenge that Robert personally did not consider crucial was the certification and patent rights protection. The certification mainly involved the risk of technical requirements standardization in the Kenyan market, especially in regulating the renewable resources market. In 2019, the Kenyan government adopted the Kenya Energy Act 2019 (Twesigye, 2022), and the Energy and Petroleum Regulatory Authority (EPRA) began to regulate the supply and use of energy, including the licensing of energy systems. For this purpose, it would be advantageous to expand the Kenyan market by leveraging the valuable know-how of an established European company operating in the market. Moreover, differences in licensing and domestic legislation are quite specific when compared even to neighbouring countries. SUN Powered Systems had highly innovative products supported on the EU market by innovation support programs and subsequently protected by intellectual property legislation (patents used in the Solar Arm). The African market was different, and there was a risk that legislation or its enforceability might need to be revised or clarified. Several years of product innovation and development could be lost in this case.

#### **4.2. Institutional support and partnership**

For the product in this "East African corner", after consulting with the economic diplomacy of the Slovak Republic at the Embassy of Slovakia in Nairobi, there are more examples of the companies that were the first in their segment on the market and expanded very successfully. One CEO of an important Slovak company remarked at the time with the words that "you rarely achieve a high margin in a safe and saturated market." The economic diplomat on the local market had accumulated knowledge during several decades of presence on the market; they were ready to help Robert, particularly with the initial overcoming of technical obstacles in foreign trade (certificates, confirmations of product conformity, alignment of technical standards, contacts with local authorities regulating the energy market, etc.).

Last but not least, there was SARIO. An agency with several specialists for African markets who were available as part of state services focused on pro-export and especially pro-investment nature. Should Robert decide to expand with his company on the Kenyan market using more capital-intensive forms (establishment of a branch, office, production facility), specialists from SARIO were prepared to share their experience and highlight key aspects of such a contract and the entire process of establishing a company in cooperation with the embassy.

Eximbanka was the final alternative that was considered for expansion. This state-financed bank in the Slovak Republic was intended for Slovak exporters and investors abroad. Its primary purpose aligned with the situation in which this start-up found itself: to finance expansion into markets where the company would have preferred to avoid operating under

typical business case under market conditions. For Robert, it was primarily an opportunity to access credit options for exporting and export insurance in case of non-payment or payment discipline issues on the part of a foreign business partner. This not only made bank financing more accessible and cheaper but also reduced the risks of expansion in this foreign market considerably.

A month before the official event under the political auspices of both governments, and after listening to the presentation in Amsterdam, Robert was contacted by an essential player in the European agro mechanisms market, HenkAgro Group<sup>2</sup>, and approached him with cooperation. He first introduced the company, which offers a wide range of agricultural machines and their operation and opportunities to apply in the Kenyan market. For decades, the Dutch government has actively supported its exporters and investors in the Kenyan market within the institutionalization framework and a rich history in economic diplomacy. They have long-term experience and companies with a long tradition in the region (e.g., many cut flowers in the EU are imported via the Netherlands). In addition to their rich experience in the Kenyan market (certification of products, technical standards, consumer protection), they provided Robert with the opportunity to customize his production specifically for the Kenyan market. However, during the subsequent meeting, the Dutch partner explained to Robert the challenges of the Kenyan market and clarified that the cooperation model would not involve direct confrontation of the Slovak company with the Kenyan market, but rather that SUN Powered Systems would receive a commission of approximately 4% based on the value of each exported machine.

## **5. Dilemma point in the managerial decision – method of the Kenyan market expansion**

Solar Arm is undoubtedly a prospective energy product for low and middle-income countries worldwide. However, Robert knew that the Kenyan market was particular and more demanding than the EU markets where he has been moving so far. On the other hand, it was a very underserved market. Unlike the EU, the rapid population growth, the sales of agricultural production, and especially the available space for innovative energy products offer many opportunities. Additionally, the patronage of the Slovak president over cooperation events served as an important catalyst for building contacts, where there was only a tiny likelihood of a dysfunctional, fraudulent company on the Kenyan side within such a forum. After consulting with an economic diplomat and reviewing the possibilities of expanding into the foreign market (The Slovak Embassy in Nairobi, Kenya, 2022), the key issues to decide were:

- choosing a specific method of expansion in the Kenyan market,
- selection of the capital-intensive expansion model in the foreign market and engagement of an external partner in this area.

Companies that decide to expand into the foreign market have a range of options available for how to realize this market penetration and reach a wider range of customers. According to Hill (2022) and Zabojsnik and Ciderova (2022), the basic options include the following:

- wholly owned subsidiaries (foreign direct investment: greenfield),
- joint venture, mergers or acquisitions,
- direct exporting,
- indirect exporting (export alliance, piggy-backing etc.),
- turnkey contracts,

---

<sup>2</sup> With regard to the company's trade secret, this is a fictitious company name but a real offer.

- licensing,
- franchising.

In the case of SUN Powered Systems, Robert primarily considered the preservation and utilization of his patents in the field of energy innovations, which he could expand and constantly innovate in the final product (BASF Innovation Hub, 2022). However, simultaneously, he was mindful of the substantial capital needed for innovations; many of them were experimental and not fully applicable to the market. Without practical innovations, the Solar Arm would not have been built. In this context, the Dutch offer of a "safe haven" guaranteeing a net profit of 4%, kept appearing in front of his eyes, but he knew that his start-up probably would not grow quickly from such a scheme. Can the company go independently into Kenya's promising agricultural energy market? A fantastic challenge and great potential, but so many specifics of the Kenyan market compared to European standards pose significant questions.

Some experienced businessmen go to the foreign market through excellent contact, and in Asia, there are markets where, according to their expression, "you can sell anything." However, this is a different situation. SUN Powered Systems brings a unique, energetically innovative product with tremendous consumer potential.

- Does the Solar Arm product have the potential for farmers as an innovative energy and technological solution? Do society, community, and Kenyan farmers need and can pay for this energy-efficient product for productivity growth concerning living standards?
- If so, what is the appropriate expansion method for this foreign market? Go into this challenging (in terms of foreign trade technique) foreign market individually, and is the risk worth the opportunity, or play it safe and share the margin with a more experienced player who gets access to the company's patents (a strategic asset)?
- Is it possible to realize the expansion of an energetically innovative way of farming in the form of SUN Powered Systems to the Kenyan market on your own without capital assistance from an external partner?

In a month, with the participation of leading political representatives, his product will indeed, as usual, reap great success from the Kenyan energy industry and especially farmers during the presentation. But whom will he address regarding his preferred expansion method in the Kenyan market at the convention hall? Will he target importers, traders, Kenyan investors, government agencies, or the segment of small and medium-sized farmers? It all depends on the choice of a specific expansion method into the Kenyan market.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Acknowledgments:** The author would like to thank the Fulbright Commission in Slovakia and the Embassy of the Slovak Republic in Nairobi, Kenya, for their support and professional help with the information in this case study. Special thanks belong to the main character of the case study – Robert Demko, and his will to support the case study writing and willingness to share the data and fundamental problems of the company.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

- Agyekum, E. B. (2024). Is Africa ready for green hydrogen energy takeoff? A multi-criteria analysis approach to the opportunities and barriers of hydrogen production on the continent. *International Journal of Hydrogen Energy*, 49, 219-233. <https://doi.org/10.1016/j.ijhydene.2023.07.229>
- Andersen, M. M., Ogallo, E. & Diniz Faria, L. G. (2022). Green economic change in Africa—green and circular innovation trends, conditions and dynamics in Kenyan companies. *Innovation and Development*, 12(2), 231-257. <https://doi.org/10.1080/2157930X.2021.1876586>
- Anser, M. K., Khan, K. A., Umar, M., Awosusi, A. A., & Shamansurova, Z. (2024). Formulating sustainable development policy for a developed nation: exploring the role of renewable energy, natural gas efficiency and oil efficiency towards decarbonization. *International Journal of Sustainable Development & World Ecology*, 31(3), 247-263. <https://doi.org/10.1080/13504509.2023.2268586>
- Balaz, P., & Bayer, J. (2019). Energy prices and their impact on the competitiveness of the EU steel industry. *Prague Economic Papers*, 2019(5), 547–566. <https://doi.org/10.18267/j.pep.715>
- BASF Innovation Hub. (2022). *Czechia and Slovakia live event: Product introduction* [Video]. Available online: <https://www.youtube.com/watch?v=oZkw87ExgeM&t=4884s>
- Baur, S., Sanderson, B. M., Seferian, R., & Terray, L. (2024). Solar radiation modification challenges decarbonization with renewable solar energy. *Earth System Dynamics*, 15(2), 307-322. <https://doi.org/10.5194/esd-15-307-2024>
- British International Investment. (2021). *Climate-smart farm investments will pay dividends for Kenya and planet*. Available online: <https://www.bii.co.uk/en/news-insight/insight/articles/climate-smart-farm-investments-will-pay-dividends-for-kenya-and-planet/>
- Cerna, I., Elteto, A., Folfas, P., Kuznar, A., Krenkova, E., Minarik, M., Przewdzicka, E., Szalavetz, A., Tury, G., & Zabochnik, S. (2022). *GVCs in Central Europe — A perspective of the automotive sector after COVID-19*. Bratislava: Vydavateľstvo Ekonom. Available online: <https://gvcsv4.euba.sk/images/PDF/monograph.pdf>
- Chepkoech, W., Mungai, N. W., Stober, S., Bett, H. K., & Lotze-Campen, H. (2018). Farmers' perspectives: impact of climate change on African indigenous vegetable production in Kenya. *International Journal of climate change strategies and management*, 10(4), 551-579. <https://doi.org/10.1108/IJCCSM-07-2017-0160>
- Faiella, I., & Mistretta, A. (2022). The net zero challenge for firms' competitiveness. *Environmental and Resource Economics*, 83(1), 85–113. <https://doi.org/10.1007/s10640-022-00652-7>
- FAO. (FAO in Kenya). (2022). *Kenya study shows investing in farmers unlocks potential*. FAO Investment Centre. Available online: <https://www.fao.org/kenya/news/detail-events/en/c/1492869/>
- Fu, C., Lu, L., & Pirabi, M. (2024). Advancing green finance: a review of climate change and decarbonization. *Digital Economy and Sustainable Development*, 2(1), 1. <https://doi.org/10.1007/s44265-023-00026-x>
- Hill, C. W. L. (2022). *Global business today* (12th ed.). McGraw-Hill.
- Hill, C. W. L., & Hult, G. T. M. (2019). *ISE Global Business Today* (11th ed.). McGraw-Hill Education.
- International Trade Administration. (2022). *Kenya – Country Commercial Guide. Perspectives in Agribusiness*. Available online: <https://www.trade.gov/country-commercial-guides/kenya-agribusiness>
- Kenya Agricultural Research Institute. (2022). *The Major Challenges of the Agricultural Sector in Kenya*. Available on: <https://www.kari.org/the-major-challenges/>
- Nagaj, R., Gajdzik, B., Wolniak, R., & Grebski, W. W. (2024). The impact of deep decarbonization policy on the level of greenhouse gas emissions in the European Union. *Energies*, 17(5), 1245. <https://doi.org/10.3390/en17051245>
- Nazari, M. A., Rungamornrat, J., Prokop, L., Blazek, V., Misak, S., Al-Bahrani, M., & Ahmadi, M. H. (2023). An updated review on integration of solar photovoltaic modules and heat pumps towards decarbonization of buildings. *Energy for Sustainable Development*, 72, 230-242. <https://doi.org/10.1016/j.esd.2022.12.018>
- Ndung'u, N., Thugge, K., & Otieno, O. (2011). *Unlocking the future potential for Kenya: The Vision 2030*. Office of the Prime Minister, Ministry of State for Planning, National Development and Vision 2030.
- Nduru, G. (2011). *Structure of Traditional Agriculture in Kenya 2011. The structure and Importance of Traditional Agriculture in Kenya*. Available online: <https://iu.pressbooks.pub/travelingfarmer/chapter/1304/>
- Odhiambo, N. M. (2022). Foreign direct investment and economic growth in Kenya: An empirical investigation. *International Journal of Public Administration*, 45(8), 620-631. <https://doi.org/10.1080/01900692.2021.1872622>

- Pinto, M. C., Simoes, S. G., & Fortes, P. (2024). How can green hydrogen from North Africa support EU decarbonization? Scenario analyses on competitive pathways for trade. *International Journal of Hydrogen Energy*, 79, 305-318. <https://doi.org/10.1016/j.ijhydene.2024.06.395>
- Stern, N. (2006). *Stern Review: The economics of climate change*. London. Archived from the original on March 9, 2010.
- Strathmore University and Microsoft. (2021). *Mapping Policies and Structures for Kenya's Preparedness for Digital Agriculture* [Research Commissioned by Microsoft]. Available online: [https://news.microsoft.com/wp-content/uploads/prod/sites/133/2021/10/AI-in-Agriculture-whitepaper\\_double-spread\\_8.6.2021.pdf](https://news.microsoft.com/wp-content/uploads/prod/sites/133/2021/10/AI-in-Agriculture-whitepaper_double-spread_8.6.2021.pdf)
- The Slovak Embassy in Nairobi, Kenya. (2022). *The embassy materials* [Internal materials presented during a public lecture on December 23, 2022].
- Twesigye, P. (2022). *Understanding structural, governance and regulatory incentives for improved utility performance: The case of Kenya and its Kenya Power* [Preprint]. Preprints. <https://doi.org/10.20944/preprints202202.0269.v1>
- U.S. Small Business Administration Office of Advocacy. (2019). *Small businesses generate 44 percent of U.S. economic activity*. Available online: <https://advocacy.sba.gov/2019/01/30/small-businesses-generate-44-percent-of-u-s-economic-activity/>
- USAID. (2019). *Off-grid solar market assessment Kenya* [PDF]. Available online: [https://www.usaid.gov/sites/default/files/documents/1860/PAOP-Kenya-MarketAssessment-Final\\_508.pdf](https://www.usaid.gov/sites/default/files/documents/1860/PAOP-Kenya-MarketAssessment-Final_508.pdf)
- Valaskova, K., Nagy, M., Zabochnik, S., & Lazaroiu, G. (2022). Industry 4.0 wireless networks and cyber-physical smart manufacturing systems as accelerators of value-added growth in Slovak exports. *Mathematics*, 10(14), 2452. <https://doi.org/10.3390/math10142452>
- Wagner, N., Rieger, M., Bedi, A.-S., Vermeulen, J., & Demen, B.-A. (2021). The impact of off-grid solar home systems in Kenya on energy consumption and expenditures. *Energy Economics*, 99, 105314. <https://doi.org/10.1016/j.eneco.2021.105314>
- World Bank Group. (2023). *Global Solar Atlas*. Energydata.info. Available online: <https://globalsolaratlas.info/download/kenya>
- World Bank Group. (2025). *DataBank: Population Estimates and Projections*. Available online: <https://databank.worldbank.org/source/population-estimates-and-projections>
- Zabochnik, S., & Ciderova, D. (2022). *International business: Issues, cases and materials* (1st ed.). Bratislava: Vydavateľstvo EKONOM.

## Appendix A

*Figure A1: Solar Arm plowing the soil (potatoes)*



## Appendix B

Table B1: Net weight of the product parts (12 m arm)

| Part                                              | Weight        |
|---------------------------------------------------|---------------|
| rotating axis, central body (arm)                 | 85 kg         |
| rotating axis with grounding screws               |               |
| long part of the arm (6 m) with solar panels 2kWp | 260 kg        |
| undercarriage                                     | 120 kg        |
| tool holding device                               | 35 kg         |
| LiFePo4 battery 5,8kWh                            | 35 kg         |
| motor part                                        | 40 kg         |
| tool for preparing soil                           | 65 kg         |
| <b>Total</b>                                      | <b>640 kg</b> |

## Appendix C

Table C1: Transportation costs overview

| Parameter                                    | Value                        |
|----------------------------------------------|------------------------------|
| Total weight (netto)                         | 1,920 kg (LCL)               |
| Transportation costs (FOB-CIF)               | 1,280 € (Slovakia – Mombasa) |
| Volume                                       | 6.00 m <sup>3</sup>          |
| Delivery from port to port (Hamburg-Mombasa) | 45 days                      |
| Customer duty + custom clearance             | N. A.                        |
| Local fees in Mombasa                        | N. A.                        |

\*Comment: total costs for FCL is 2 800 €

## Appendix D

### SUN powered systems: Expanding EU green innovations under the African sun<sup>3</sup>

#### 1. Case overview

The study is devoted to the highly innovative energy product from the EU (Slovakia), designed as a result of the stringent decarbonization policy and ready to penetrate the Kenyan agricultural market. The Solar Arm uses several patents to perform autonomous plowing, planting, and irrigation, fully powered by photovoltaic panels. Additionally, battery capacity storing the electricity enables solving several problems of Kenyan small and medium farmers related to electricity deficits. The challenge associated with entering the Kenyan market lies in the critical assessment of its suitability for such a highly innovative and eco-friendly product developed in the “green EU.” As a result—ultimately—a managerial decision must be made. Readers will have to determine the appropriate expansion method for the Kenyan agricultural market for this Slovak start-up.

#### 2. Learning objectives

The following learning objectives outline the key competencies and knowledge areas that students are expected to develop upon completion of this module:

- students can understand Porter hypothesis and the potential positive externalities stemming from environmental regulation,

---

<sup>3</sup> Teaching note

- a brief overview of the EU decarbonization efforts and relation to export competitiveness,
- market overview of the Kenyan economy and particularly Kenyan agriculture, its main features and specifics,
- have a brief overview of the export price calculation,
- understand basic and advanced methods of foreign markets expansion,
- critically assess the advantages and disadvantages of particular foreign market expansion methods,
- overview of the macro and micro business environment of foreign markets.

### 3. Pedagogy

The business case is suitable for bachelor and MBA classes of business-oriented study programs), business disciplines (suitable for business-oriented programs, particularly for those focused on energy market low and middle-income countries, international studies), and prerequisite knowledge or courses (general economic theory, entrepreneurship basics, basics of global logistics).

### 4. Recommended supplemental materials

Recommended supplemental materials cover:

- European Commission. (n.d.). *European Green Deal: Decarbonization policies of the EU*. European Commission. Available online: [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en)
- Council of the European Union. (n.d.). *Fit for 55 Package: The EU plan for a green transition*. Available online: <https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/>
- Strathmore University & Microsoft. (2021). *Mapping policies and structures for Kenya's preparedness for digital agriculture* [White paper]. Available online: [https://news.microsoft.com/wp-content/uploads/prod/sites/133/2021/10/AI-in-Agriculture-whitepaper\\_double-spread\\_8.6.2021.pdf](https://news.microsoft.com/wp-content/uploads/prod/sites/133/2021/10/AI-in-Agriculture-whitepaper_double-spread_8.6.2021.pdf)
- Hill, C. W. L., & Hult, G. T. M. (2022). *ISE Global business today* (11th ed.). McGraw-Hill Education.
- Daniels, J. D., Radebaugh, L. H., Sullivan, D. P., & Salwan, P. (2016). *International business*. Pearson India.
- Cerna, I., et al. (2022). *GVCs in Central Europe: A perspective of the automotive sector after COVID-19* (Chapter 2).
- Krajcik, S., Zabožnik, D., & Ciderova, D. (n.d.). *Competitiveness in international business* (Chapter 4).
- BASF. (2022). *Solar Arm – Product introduction at BASF Innovation Hub: Czechia and Slovakia live event* [Video]. YouTube. Available online: <https://www.youtube.com/watch?v=oZkw87ExgeM&t=4884s>

### 5. Assignment questions

The following questions are designed to guide your analysis and critical thinking based on the information provided in the case study.:

RQ1: *What are the potential impacts of stringent environmental regulations?*

RQ2: *Would this innovative energy market product suit low- and middle-income countries?*

RQ3: *What kind of direct or indirect method of Kenyan market expansion is the most appropriate?*

## 6. Case analysis

To deeply analyze the text and content of the case study, I strongly suggest to be focused on the problem in the following structure.

### 6.1. What the potential impacts of stringent environmental regulations?

It is expected to discuss the pros and cons of stringent environmental regulations within the energy market of the EU. It has to be highlighted as a necessity for the decarbonization efforts. The conclusion to this question has to be clearly defined as a possible presence of the Porter effect<sup>4</sup>.

The also negative impact of the decarbonization policy has to be clarified. Mainly through a potentially lower consumption due to higher prices (environmental regulation costs). During the discussion, it is recommended to raise a question concerning globally needed environmental measures (CO<sub>2</sub> reduction). It must be stressed that ecological regulation can negatively affect businesses in case of incorrect policy design. As a crucial legacy of the European Commission, the case study participants must be assured about an essential pillar of industrial competitiveness and boosting innovation activity triggered by the decarbonization policy.

### 6.2. Would this innovative energy market product suit low- and middle-income countries?

Firstly, it has to be stressed and clarified among the students that the decarbonization efforts have to be implemented at the global level due to the possible phenomenon of carbon leakage (undesired migration of the corporations establishing businesses in countries with a weaker environmental standard: “environmental colonialism”). Even developing countries and LDCs have their carbon emissions objectives to set. Moreover, better ecological standards within LMIDC help them to protect their natural environment locally. Additionally, clean production helps to place their exported products on western markets more efficiently. Due to high economic growth, these countries need to build incremental energy capacity, which has to be sustainable (renewable) as much as possible. For this purpose, exporting the most recent (advanced) and environmentally friendly technologies from the EU and the USA is crucial. In this regard, the product of the solar arm would also fulfill the environmental objectives in the Kenyan agro sector.

Moreover, technology helps increase the productivity rate and, therefore, the general standard of living. Besides the environmental standards that the Kenyan government must support, several other factors favor solar arm usage. They include higher productivity, battery, and spared electricity disposal (smartphone, home electric appliances, water usage, irrigation usage). Additionally, the solar arm brings pesticides, herbicides, and fungicides savings.

One of the most significant Solar Arm benefits represents the disposal of autonomous energy systems (fossil fuels, logistics on pure quality roads.) Comparing tractors, the reliability of the

---

<sup>4</sup> M.E. Porter has been dealing with this phenomenon since the 1990s. Based on research in American companies, he formulated the so-called Porter's hypothesis, which assumes that strict environmental regulation causes restrictions or increases costs and this forces companies to introduce innovative solutions to reduce energy consumption or increase productivity. Ultimately, these local restrictions (regulation) bring companies higher international competitiveness (export competitiveness) caused by technological innovations, the introduction of cleaner production technologies or more efficient production processes.

equipment is higher. Therefore, small or medium farmers do not need bigger cities to purchase spare parts frequently. The most critically assessed question has to be dealing with the product's affordability. Based on the brief calculation within the case study, the students have to critically determine a crucial need for flat revenues of the farmers based on fixed supplies. Without this "prepaid goods delivery" model and/ or government subsidy, investing 20 000- 30 000 € for a small or medium African farmer would be impossible.

### **6.3. What kind of direct or indirect method of Kenyan market expansion is the most appropriate?**

First, any method used for Kenyan market penetration would not be possible without government support - without Slovak pro-export institutional support (economic diplomat from the embassy, SARIO, Eximbanka). Secondly, the students have to identify capital-intensive and non-intensive methods of foreign market expansion (from the list of methods). Initially, they have to take away capital-intensive methods related to wholly owned enterprises on foreign markets. As a second point, they should determine a possible direct or indirect exportation, advantages and disadvantages of this method. For this purpose, they have to briefly calculate the import price to Kenya (value of the Solar Arm of 18 000 €, transport costs, and customs duty as a DDP price).

*Table D1: Entry modes on foreign market, advantages and disadvantages*

| <b>Entry mode</b>         | <b>Advantages</b>                                                                                                                      | <b>Disadvantages</b>                                                                                                                                    |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Exporting                 | Ability to realize location and experience curve economies                                                                             | High transport costs<br>Trade barriers<br>Problems with local marketing agents                                                                          |
| Turnkey contracts         | Ability to earn returns from process technology skills in countries where FDI is restricted                                            | Creating efficient competitors                                                                                                                          |
| Licensing                 | Low development costs and risks                                                                                                        | Lack of long-term market presence                                                                                                                       |
| Franchising               | Low development costs and risks                                                                                                        | Lack of control over technology<br>Inability to realize location and experience curve economies<br>Inability to engage in global strategic coordination |
| Joint ventures            | Access to local partner's knowledge<br>Sharing development costs and risks<br>Politically acceptable                                   | Lack of control over quality<br>Inability to engage in global strategic coordination                                                                    |
| Wholly owned subsidiaries | Protection of technology<br>Ability to engage in global strategic coordination<br>Ability to realize location and experience economies | High costs and risks                                                                                                                                    |

*Source: Hill and Hult (2019)*

The discussion within the class should be focused on the mentioned advantages and disadvantages of the particular methods.

## **7. Conclusions**

After critical points discussion (particular method advantages and disadvantages, capital intensity, potential theft of technological know-how, price competitiveness, distribution network, specific customer preferences, difficult certification, etc.) The students must identify the following expansion methods as potentially acceptable:

- indirect export to a big Kenyan agricultural supplier on the parity-CIF Mombasa,

- sold patent rights for Kenyan (east-African market) 3. Joint venture – 50/50 shareholders' equity – Robert Demko would pay the shareholder equity by the intangible asset's value (technological patents of the products).

## 8. Teaching plan

The following table outlines the time-structured teaching plan for the session, including the main topics, focus areas, and learning goals.

*Table D2: Time-structured teaching plan*

| Time      | Content                                                                                                                                                                               |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1-13 min  | Characteristics of the decarbonizations efforts in the EU. Possible negative effect on the industrial exporters. Porter's hypothesis.                                                 |
| 13-15 min | Institutional support, problem of the Slovak (and many other) smaller countries in economic diplomacy and institutional support of the exporters and investors abroad.                |
| 16-30 min | Characteristics of the product, its competitiveness, advantages, unique parameters and problem-solving potential (perceived value). Potential of electricity storage and usage.       |
| 31-60 min | Kenyan agriculture and potential for business. A brief SWOT analysis of the market potential in agriculture. Match between the market potential in Kenya and the product (Solar Arm). |
| 61-90 min | Potential foreign market entry modes (methods). Advantages and disadvantages. Conclusions.                                                                                            |

## EXAMINING THE COMMUNICATION OF CSR INITIATIVES: EVIDENCE FROM LIDL SLOVAKIA

Katarina Rezakova<sup>1,a</sup>, and Katarina Zvarikova<sup>1,b,\*</sup>

<sup>1</sup>University of Zilina, Faculty of Operation and Economics of Transport and Communications,  
Department of Economics, Univerzitna 1, 010 26 Zilina, Slovakia

<sup>a</sup>rezakova4@stud.uniza.sk, <sup>b</sup>katarina.zvarikova@uniza.sk

\*Corresponding author

**Cite as:** Rezakova, K., Zvarikova, K. (2025). *Examining the Communication of CSR Initiatives: Evidence from Lidl Slovakia*, *Ekonomicko-manazerske spektrum*, 19(1), 117-128.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.117-128](https://dx.doi.org/10.26552/ems.2025.1.117-128)

---

*Received: 8 March 2025; Received in revised form: 11 May 2025; Accepted: 30 May 2025; Available online: 30 June 2025*

### Abstract:

*Research background:* Many studies are focused on the benefits of CSR implementation. Nevertheless, all of the benefits are tied to proper communication, as if a company lacks the ability to effectively communicate its CSR activities, the potential benefits of implementation may fail to be realised. Many companies use non-standardised reports, but most of them use ESG as the criterion for assessing their CSR development.

*Purpose of the article:* The purpose of the article is to examine the level of consumers' awareness and perception of ESG reports and CSR activities communicated by Lidl Slovak Republic. The study aims to identify how effectively these activities are reaching consumers and influencing their perception of the company's transparency.

*Methods:* For this case study, the Lidl Slovak Republic was selected, which is perceived as a responsible company. This company communicates its CSR activities through various communication channels. A survey was chosen for achieving the aim of the study.

*Findings & Value added:* The survey results show that respondents are familiar with Lidl's various CSR activities, and the main communication channels, such as advertising or in-store advertisements, are more familiar to respondents. A not too surprising finding is that only a small part of the respondents is familiar with Lidl's non-financial reports. However, if they are familiar, they perceive the company as more transparent. Regarding the relationship between age and the perception of Lidl as a transparent company, a dependence was confirmed. The results of our study can serve as a basis for further research. This should primarily focus on why consumers who consider CSR activities beneficial are not familiar with the company's reports and only know those that are promoted, e.g. through advertising.

**Keywords:** CSR; communication; ESG; survey

**JEL Classification:** M14; M37

## 1. Introduction

In the last two decades, the scientific discourse has increasingly focused on the responsibility that companies should take. Despite the high level of interest in the issue, there is no consensus on the extent of taking responsibility, and authors take different approaches to defining it. For

example, McGuire et al. (1988) argue that the responsibility of organisations goes beyond economic and legal expectations. This insight is complemented by Davis and Blomstrom (1975), who consider the character of the individual as the primary determinant affecting the social responsibility of companies. Authors also have different views and opinions on how responsibility should be enforced, with Walton, for example, preferring voluntariness over coercion, which is agreed by the majority of authors (Isa, 2012). Although there is no consensus on defining responsibility, the definitions are similar in terms of voluntariness, transparency, or the perception of business in a broader context that is not focused solely on maximising profit, but on achieving it in a way that respects economic, social, and environmental responsibility (Zvarikova, 2023).

However, the concept of corporate social responsibility is not only the domain of the scientific community, but also of regulated bodies, multinational organisations, and, recently, an increasing number of consumers have begun to deal with it, which represents a shift from the theoretical to the practical level. Several studies have been conducted on the positive impact of CSR, confirming that the implementation of CSR activities in business practice brings benefits in various areas of business. In terms of economic results, the implementation of CSR has a positive effect on word-of-mouth, in the long term, costs are reduced, attractiveness for investors increases, and companies also become preferred business partners (Alhouti et al., 2021; Wang and Dong, 2025; Zvarikova, 2023). In terms of marketing benefits, a positive impact on the reputation of the company has been confirmed, even in times when the company and its reputation are affected by an adverse event (Kang et al., 2021). At the same time, CSR implementation has a positive effect on employees (Rozsa et al., 2021) and reduces their turnover (Vveinhardt and Sroka, 2020). In addition, CSR also supports business transparency (Enz et al., 2021).

Nevertheless, all of the aforementioned benefits are tied to proper communication, as if a company does not know how to communicate its CSR activities properly, the benefits of implementation often do not materialise (Wang and Dong, 2025; Sareen and Mahajan, 2025; Hu, 2025). For this reason, it is essential to know how to communicate properly internally and externally. For this case study, the Lidl Slovak Republic (for here and after Lidl) company was selected, which is perceived as a responsible company, which is proven not only by various surveys, but also by awards such as Top Employer, and it is also a Partner of the Fund for Transparent Slovakia of the Pontis Foundation, etc. (Lidl Slovak Republic 2024; Lidl Slovak Republic 2025). As part of the survey, we focused on the communication of Lidl's CSR activities and how it is perceived by one of the most important stakeholder groups, namely customers. The aim of the presented article is: To examine consumers' familiarity with ESG reports and CSR activities of Lidl.

The structure of the article is as follows. The Introduction defines the purpose of the study and the basic assumptions for ESG reports as one of the effective options for communicating CSR activities. At the same time, this chapter also discusses the negative connotation of ESG reports. The second chapter, Methodology, describes the implementation of the case study and the methodology used to obtain the results. The Results and Discussion chapter focuses on a critical assessment of the survey results in the context of the world's professional literature. The Conclusions chapter summarises the basic findings of our case study and outlines possible future directions of the research.

## 2. Literature review

ESG is a comprehensive framework that aims to provide an overview to an organisation's stakeholders about how a company addresses the risks and opportunities associated with aspects that are collectively known as ESG factors. The individual areas of the ESG concept follow the CSR pillars. Environmental aspects follow the environmental pillar of CSR. The same principle applies to the social aspects of ESG, which are similar to those in the social pillar. However, the difference is in the last area of ESG, namely governance, which is not focused only on the economic area of business, but mainly on the way the organisation is led and managed, i.e. the alignment of stakeholder expectations, especially investors, such as the perception and respect of shareholder rights, with internal controls for transparency and accountability by management (Petery, 2023). This area is critical because companies face constant pressure from shareholders and other stakeholders to improve results in the area of social responsibility (Kazmierczak, 2022).

An ESG report is a summary of all collected non-financial information about a company. The company thus increases its transparency towards all stakeholders. Such a report is usually published once a year, and the company evaluates the results of its activities to date and sets goals in given areas for the following year. ESG reporting is therefore aimed at satisfying stakeholders' demand for non-financial information from companies. However, as Jambor and Zanocz (2023) state, it has recently become a popular greenwashing tactic without any standardised regulatory system. This trend needs to be changed, as ESG reporting is one of the most valuable sources of information for stakeholders' decision-making. However, as Arvidsson and Dumay (2022) point out, many organisations believe that their ESG reporting strategy is an indicator of the organisation's actual performance. However, perceived performance often does not correspond to actual performance, because mandatory ESG reporting will improve performance only under certain conditions. Therefore, even if an organisation intends to improve its performance, it may not achieve the expected results due to, for example, environmental constraints.

ESG is increasingly being used in so-called ESG ratings, where they have gained attention mainly from the financial sector. Some authors emphasise that companies with strong ESG performance have access to cheap capital, thereby increasing their overall performance (Chen and Fan, 2024). This finding is also supported by the results of research by Isack and Aschauer (2025), which indicate that the implementation of a positive ESG rating positively affects lending decisions and highlights the importance of decision-making based on the credibility of CSR reports and ESG ratings. The authors of the study, Chen and Fan (2024), examined the impact of ESG ratings on company performance with a focus on achieving sustainable development and corporate sustainability through innovation in the context of high-quality global economic growth. Their findings suggest a significant positive relationship between ESG ratings and company performance. ESG ratings enhance company performance by alleviating financial constraints and improving company reputation. They also argue in their study that the effects of ESG ratings are more pronounced in organisations with strong internal controls and in private companies. Their research provides empirical evidence to support ESG investment and rating system improvements.

On the one hand, we can see an increase in ESG reports and ratings. However, practice also points to various problems associated with, for example, the lack of experts in companies and the associated publication of inaccurate or incomplete data, manipulation of data through greenwashing, increased administrative burden on companies, ambiguities in ever-changing legislation, but also the diversity of ESG ratings (Spaniol, 2024; Jambor and Zanocz, 2023). Berg et al. (2022) cite, for example, three main reasons for the differences in ratings - different

measurement (56% share of total differences), different rating scope (38% share of total differences) and, last but not least, the deviation of weights (6% share of total differences).

All these findings suggest that ESG reports are not standardised and do not adequately represent the sustainable performance of a company. Therefore, they highlight the complexity and limitations associated with ESG ratings and call for different understandings and cautious interpretation of the results (Jambor and Zanocz, 2023). Despite these shortcomings, many companies report on ESG, which they inform about their CSR activities within the governance, environmental and social fields.

### **3. Methodology**

Many companies have understood that CSR activities support their reputation and, at the same time, help to strengthen their position in the market. They are also aware that they will achieve positive effects only if they can inform about these activities effectively. In some cases, they are legally obliged to inform about such non-financial information (e.g. Corporate Sustainability Reporting Directive), in other cases, they do so voluntarily. Based on the above, the aim of the presented article was set to examine the familiarity of consumers with ESG reports and CSR activities of Lidl.

Based on this aim, a selected group of stakeholders was determined as customers and a questionnaire survey was used to determine their attitudes and awareness regarding selected activities of Lidl, which it informs about in its ESG reports.

Since 2017, Lidl has published a sustainability report every two years, which recapitulates all the company's strategic goals, activities and projects that have a significant economic, social and environmental impact. At the same time, all stakeholders have identified them as important. Lidl is aware of the impact of its business activities on several groups of stakeholders, especially employees, suppliers, the environment and the country itself. It tries to eliminate or neutralise its negative impact precisely through its activities, which are not only aimed at generating profit, but also at respectful behaviour towards the environment, fair dealings with employees and suppliers, while still not forgetting the environment and its preservation for future generations. Lidl informs all stakeholders about its activities, commitments and achievements through detailed annual and national reports, which it regularly publishes on its website. This report is intended for Lidl's business partners, its customers, employees, the media, representatives of the public sector, the non-profit sector, other professionals and the public. Likewise, Lidl publishes a Socio-economic Study for a specific business year every year, in which it provides an overview of the positive economic impacts of its activities in the Slovak economy.

As a first step, a document analysis was carried out to identify the activities that Lidl carries out and subsequently to determine the awareness of a selected group of stakeholders - customers about the given activities.

An online questionnaire survey was used to collect data, created using the online platform Google Forms. The questionnaire was intended for residents of the Slovak Republic over 18 years of age. It contained nine questions, of which two were focused on demographic data about the respondents and seven questions were focused on the awareness and activities of Lidl in the Slovak Republic. It was sent to respondents electronically using Facebook and Instagram, and mainly by email. The questionnaire survey was carried out from 25<sup>th</sup> February 2025 to 6<sup>th</sup> March 2025 and was completed by 413 respondents.

To achieve the goal, the following hypotheses were set:

H1: *30% of respondents are familiar with Lidl's annual reports.*

H2: *There is/is no relationship between the level of familiarity with annual reports and the perception of transparency.*

H3: *There is/is no relationship between the age category of respondents and the emphasis they place on sustainability and social responsibility.*

To verify hypothesis 1, the test for the equality of proportions was used. Chi-squared test was used to verify hypotheses 2 and 3.

The test for the equality of proportions is concerned with verifying whether the observed proportion of the occurrence of a particular feature in the set (sample) matches the theoretically expected proportion. The chi-square test of independence verifies whether there is a dependence between two categorised variables. If the dependence is confirmed, then Cramer's V coefficient is used to determine the strength of the dependence. Before using the chi-square test, it was first necessary to verify that the conditions for its use were met, namely: 80% of the theoretical frequencies must be greater than five, and all theoretical frequencies must have a value of at least 1. If the conditions are not met, some categories must be merged.

When evaluating some questions, respondents were to express their opinions and preferences using a Likert scale from 1 to 5, with 1 meaning the most important factor and five the least important. The Likert scale values were, in some cases, converted to their numerical equivalents, and the arithmetic mean was calculated from them.

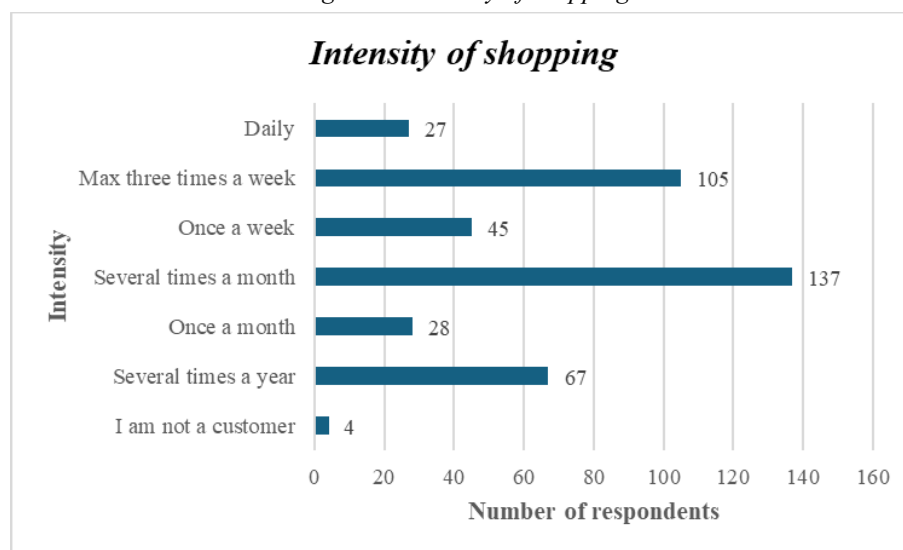
## 4. Results and Discussion

The questionnaire was completed by 413 respondents, of whom 248 were women, representing 60.05% and 165 were men, representing 39.95%.

The fewest respondents were aged 18 to 20 (4.8%). The second age category 21-30 represents 26.9% of respondents. This may be due to how responses were obtained via social networks. 13.6% of respondents were aged 31 to 40, and 13.1% of respondents were aged 41-50. The majority of respondents were aged 51-60 (30.6%), as the questionnaire was primarily distributed via email. 10.9% of respondents were classified as over 61.

The survey results (Fig. 1) show that, except for four respondents (9.7%), all are customers of the Lidl retail chain, with 42.9% of respondents shopping there at least once a week and the vast majority at least once a month (82.2% of respondents).

*Figure 1: Intensity of shopping*



*Source: own processing*

When researching the factors influencing consumers' decision to shop at Lidl, we focused not only on factors such as price or store availability, but also on the CSR or transparency factor. Respondents indicated the importance of each factor based on a Likert scale. The results show that the most important factor is low prices, followed by a good price-quality ratio, quality products, store availability, and, lastly, transparency and an emphasis on sustainability and CSR. The low-price factor was marked as the most important by more than 250 respondents. This factor only achieved ratings of 4 and 5 in a few answers, so it is clear that low prices are essential for respondents when shopping at Lidl stores. The second factor, store availability, was no longer as high a priority when shopping as the previous one. It was marked as the most important (rating 1) by 190 respondents. This is also because nowadays almost every consumer has a car and can therefore reach more distant stores, so the accessibility and proximity of stores is not a significant factor. Nevertheless, it is still important for most of the respondents. Almost every customer looks for quality products when shopping. For 208 respondents who shop at Lidl, the quality of their products is the most important reason for shopping. The less important ratings of 4 and 5 are low for this factor. This shows that respondents perceive Lidl as a seller of quality products and seek them out for this reason. This is also confirmed by the Mastercard Retailer of the Year award, or Best Buy award, which Lidl gained (Lidl Slovak Republic, 2025). The factor of good price-quality ratio is also among the important factors that respondents consider when shopping at Lidl. A total of 314 respondents marked it with a rating of 1 and 2, which is more than the other ratings of this factor. Ratings 3-5 had a total of only 89 assessments, which indicates that only a small part of the respondents perceive this factor as less important. However, in the context of CSR implementation, the emphasis on sustainability and social responsibility is not a priority factor when shopping at Lidl. Judging by the growth in ratings 3-5, which were very low in the previous factors, here, on the contrary, the assessments increased slightly. The reasons may be different, for example, that customers prefer more practical factors such as price, quality and availability when shopping, over longer-term values such as sustainability and social responsibility. Another reason may be the low level of customer awareness of Lidl's specific activities and measures in the area of sustainability. The last factor that respondents had to evaluate was transparency. This again received a high rating of 1, specifically 188 respondents rated it as the most important. Ratings 2 and 3 had similar voting results, and together, 175 respondents rated transparency as moderately important. A total of 37 respondents rated this factor as almost the least important and unimportant, i.e. ratings 4 and 5.

Point rating was used to better compare the importance of individual factors with each other. Each rating was converted to its numerical equivalent as follows: (i) rating 1 was assigned 5 points; (ii) 2 = 4 points; (iii) 3 = 3 points; (iv) 4 = 2 points; and (v) 5 = 1 point. The average number of points for an individual factor was the sum of all point ratings divided by the number of all responses (413). The results of the point rating are shown in Table 4 in descending order (Table 1).

*Table 1: Factors scoring by median*

| Factors | Low prices | Good quality /<br>price ratio | Product's<br>quality | Stores<br>availability | Transparency | CSR   |
|---------|------------|-------------------------------|----------------------|------------------------|--------------|-------|
| Median  | 3.954      | 3.644                         | 3.620                | 3.494                  | 3.477        | 3.470 |

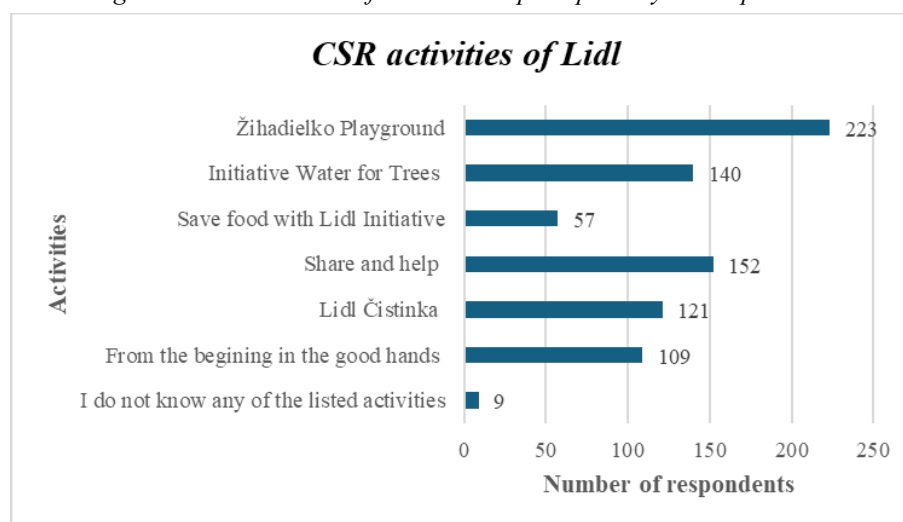
*Source: own processing*

Table 1 shows that none of the factors is significantly more important than the others. However, there is a smaller emphasis on the low-price factor compared to the others, which means that affordability plays a key role in consumers' purchasing decisions. This result is in line with, for example, the findings of Boccia et al. (2019), who found that respondents stated

it is essential for them to know whether companies engage in CSR activities. However, ultimately, price is still the main criterion that determines the choice. On the contrary, transparency (3,477 points) and emphasis on sustainability and social responsibility (3,470 points) received the lowest ratings, which indicates that customers take these factors into account, but to a lesser extent compared to the price and quality of products. However, it is important to realise that although customers do not make decisions primarily based on a company's transparency, it is a factor that is perceived by them and completes the overall perception and authenticity of CSR (Enz et al., 2021).

We also found out what CSR-oriented Lidl activities the respondents were aware of. The identification of these activities was based on the company's annual non-financial statements from 2020/2021 and 2022/2023 (Lidl Slovenska republika, 2025), which were focused on the company as a whole, so customers could perceive them more and be more responsive to them. Within this question, respondents could choose from several answers. The selected Lidl activities were: (i) Zihadielko playground (children's playground); (ii) Water for Trees initiative (tree planting in the Tatra Mountains); (iii) We Save Food with Lidl and Share and Help (food collection campaigns); (iv) Lidl Cistinka (urban park); and (v) From the Beginning in Good Hands (support for children in need). The last option was that the respondent was not aware of any activity. The results of this questionnaire question are shown in Figure 2.

*Figure 2: CSR activities of Lidl and ich perception by the respondents*



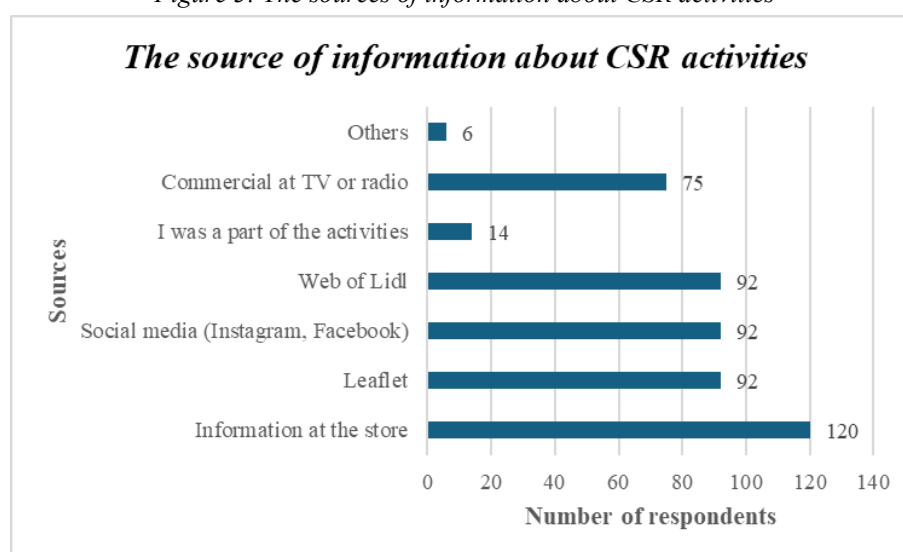
*Source: own processing*

Of the selected Lidl activities, respondents were most familiar with the first option, the Zihadielko playground, which was being built in 50 Slovak cities between 2016 and 2021. This project involved customers in voting on the cities in which a playground could be built. The playgrounds are intended for children aged 2-12. It is probably the best-known project of Lidl, precisely because it connected Lidl and the community throughout Slovakia. This activity was known by 54% of respondents. The second most well-known activity among respondents was the food collection Share and help. This activity was known by 36.80% of respondents. The food collection takes place in all Lidl stores throughout the year. Customers can contribute a part of their purchase to the collection. Each store has a specific organisation that it supports, and the collected food thus stays and helps directly in the region. The Water for trees initiative completes the top 3 most well-known Lidl activities among respondents. This activity was known to 33.90% of respondents, perhaps because of its long history. This project has been operating since 2012 on the principle that for every 1.5-litre bottle of Saguaro mineral water

sold, Lidl donates 1 cent to planting trees in the disaster-ravaged Hight Tatras. Since the beginning of this project, more than 2,000,000 trees have been planted. 29.30% of respondents were familiar with Lidl Cistinka. It is a city park project that is known among the public as it is intended for children, teenagers, parents and seniors. The project has been operating since 2022, and Lidl Cistinka is currently built in 7 cities in Slovakia and is being prepared in another 8. 26.39% of respondents were familiar with the activity From the beginning in good hands. This activity represents assistance for families with children with severe disabilities. It has been operating since 2018 on the principle that for every pack of Lupilu diapers sold, Lidl donates 10 cents to help these families (Lidl Slovenska republika, 2025). Less well-known activities include the initiative with Lidl, I save food, which was known by only 13.80% of respondents. Customers certainly know this activity, but not under a single name, which is why there are fewer votes in this option. Only 2.18% of respondents to the questionnaire were unaware of any Lidl activity. It follows from the above that respondents are mainly aware of those activities that are communicated through advertising in the mass media or social networks (such as the Zihadielko playground), or through advertising directly in the store (such as the Share and Help initiative). Those activities that are communicated less do not have such a high level of perception by consumers. The results are in line with Sareen and Mahajan (2025), who claim that properly communicated activities aimed at the public and especially at identified key stakeholders then have a positive impact on creating and maintaining a good image of the company. It is also important to realise that, like the CSR concept itself, the way it is communicated has evolved from one-way communication to two-way communication, which is now focused not only on informing about corporate activities within the concept, but it is also addressed to key stakeholders to listen and reflect their interests, with one of the main benefits of properly conducted communication being transparency (Lim and Greenwood, 2017).

The next important step was to find out where the respondents learned about Lidl activities, and what their primary source of information was. They had the following options: directly from stores, from flyers, social networks (Instagram, Facebook), Lidl website, I was/was part of them, advertising on radio or TV, and others. The results of the answers to this question are shown in Figure 3.

*Figure 3: The sources of information about CSR activities*



*Source: own processing*

The results show that the largest share, namely 29.06% of respondents, obtain this information directly from Lidl stores, which indicates that the physical presence and

communication in stores play a key role in disseminating information about the company's activities. The same share of respondents, i.e. 22.28%, stated that they learn about Lidl's activities through leaflets and social networks such as Instagram and Facebook. This points to the importance of digital communication and traditional promotional materials in informing customers. The third most common source of information is advertising on radio or television, which was identified as their primary source of information by 18.16% of respondents. This figure indicates that traditional media channels still play an important role in reaching the public. Only 3.39% of respondents obtain information directly from the company's website, which may indicate a lower preference for this information channel compared to social networks or personal contact. Similarly, 3.39% of respondents stated that they had even actively participated in one of Lidl's projects, thus not only becoming familiar with the company's activities, but also personally participating in them. Finally, 1.45% of respondents indicated another option as their source of information. Some of them stated that they learned about Lidl's activities thanks to personal contacts. In contrast, others admitted that they had never heard of the company's activities, which indicates that despite the company's extensive communication strategy, there are still people who are not reached by the information. These findings are interesting in the context of the findings of Hu (2025), who confirmed through his research that the communication channel is important for the perception of CSR activities as manipulative, where respondents expressed a degree of scepticism towards CSR activities on the basis that the activity was communicated as an advertisement or as a PR article. It was the PR article that respondents perceived as more trustworthy. In this context, communication channels located directly in the store seem to be the most relevant for the Slovak Republic.

According to Wang and Dong (2025), stakeholders (in the case of this study, non-professional investors) make decisions more based on the information provided in integrated reports than standalone reports. As the authors state, the integration of such reports supported by strategic communication of CSR activities influences selected stakeholders. Therefore, we investigated whether respondents had ever read Lidl's annual report. The results show that the majority of respondents, namely 80.39%, had never seen or read the company's annual report. This fact suggests that the public either lacks sufficient awareness of these documents or shows no interest in them. On the contrary, a smaller proportion of respondents, namely 19.61%, confirmed that they had already seen or read Lidl's annual report. This proportion suggests that although there is a group of informed individuals, annual reports remain a relatively little-followed source of information for the wider public. The survey results further show that the most common source of information for respondents who had ever seen or read Lidl's annual report was social networks such as Instagram and Facebook, the company's promotional leaflets or learning about the reports directly from Lidl stores. However, as Estanyol et al. (2025) emphasise, if companies want to communicate CSR activities effectively, reports must be in line with the company's activities and cannot be limited to isolated activities. As Sareen and Mahajan (2025) add, it is necessary to approach reporting strategically and transparently to satisfy the demands of various stakeholders, which are constantly changing and evolving, which will ultimately help strengthen relationships with various stakeholders and increase the positive effect of CSR activities. However, Lidl still has significant reserves in this area, as the reports focus more on setting goals for the following periods than on reflecting and measuring achievements (Lidl Slovak Republic, 2025).

Three hypotheses were set as part of the survey, which allow a better understanding of the research results.

H1: 30% of respondents are familiar with Lidl's annual reports. To test the hypothesis, the equality of proportions test was applied. Since the test statistic (-4.6065) is less than the critical

value (-1.6449), the result is statistically significant. This means that less than 30% of consumers are familiar with Lidl's annual reports. This result suggests that even though consumers declare interest in CSR activities, they ultimately do not find out more detailed information about them from non-financial reports and evaluate the company only based on the communicated activities.

H2: *It is assumed that there is/is no relationship between the level of familiarity with annual reports and the perception of transparency.* To test the hypothesis, the results of the question assessing the transparency criterion and the question focusing on whether respondents had ever read the Lidl annual report were used (Table 2).

*Table 2: Frequency distribution related to H2*

| Assessment of the factor<br>Transparency | Have you ever seen Lidl report? |     | Total |
|------------------------------------------|---------------------------------|-----|-------|
|                                          | Yes                             | No  |       |
| 1                                        | 63                              | 125 | 188   |
| 2                                        | 9                               | 75  | 84    |
| 3                                        | 4                               | 87  | 91    |
| 4                                        | 1                               | 17  | 18    |
| 5                                        | 1                               | 18  | 19    |
| Total                                    | 78                              | 322 | 400   |

*Source: own processing*

Both conditions for applying the Chi-square test were met, so it was possible to use the CHISQ.TEST function. Since the p-value is less than  $\alpha$ , we reject the null hypothesis and accept the alternative hypothesis, indicating a relationship between the level of familiarity with annual reports and the perception of transparency. Cramer's V coefficient ( $V = 0.337$ ) further confirms a moderately strong association between these two variables. This means that customers who are familiar with annual reports perceive Lidl as more transparent. This result is also consistent with the study by Sareen and Mahajan (2025).

H3: *It is assumed that there is/is no relationship between the age category of respondents and the emphasis they place on sustainability and social responsibility.* When evaluating the hypothesis, answers from the questions "What is your age?" and "Why do you shop at Lidl?" were used, specifically from the assessment of the factor Emphasis on sustainability and social responsibility (Table 3).

*Table 3: Frequency distribution related to H3*

| Age   | Assessment of the factor Transparency |     |    |    |    | Total |
|-------|---------------------------------------|-----|----|----|----|-------|
|       | 1                                     | 2   | 3  | 4  | 5  |       |
| 18-20 | 4                                     | 9   | 4  | 2  | 1  | 20    |
| 21-30 | 22                                    | 24  | 30 | 18 | 17 | 111   |
| 31-40 | 24                                    | 15  | 12 | 1  | 3  | 56    |
| 41-50 | 25                                    | 13  | 7  | 4  | 5  | 54    |
| 51-60 | 87                                    | 30  | 6  | 1  | 3  | 127   |
| 61+   | 27                                    | 9   | 9  | 0  | 0  | 45    |
| Total | 189                                   | 100 | 69 | 26 | 29 | 413   |

*Source: own processing*

Due to the failure to meet the chi-square test condition, it was necessary to merge some age categories before continuing the test. Thus, the age categories 18-20, 21-30 and 51-60, with 61+, were merged. This adjustment changed the age category ranges from the original six ranges to 4. The p-value is less than 0.000, which is well below the significance level  $\alpha = 0.05$ , indicating a statistically significant association between respondents' age categories and the importance they assign to sustainability and social responsibility. Cramer's coefficient (0.276) confirmed a weak dependence. This means that different age categories have different

approaches to sustainability as a factor that is important to them in their consumer decision-making.

## 5. Conclusions

Studies show that if companies want to benefit from their CSR activities and gain a competitive advantage, they must be able to properly inform about such activities, not only by the content of the information, but also by choosing the proper means of communication. On the other hand, the question arises whether consumers, as important stakeholders, perceive CSR activities at all and proactively seek information about them, e.g. through ESG reports. This article is therefore based on a case study of Lidl in the Slovak Republic, since this retail chain is considered responsible in the Slovak Republic and informs various stakeholders and society about its activities.

The aim of the article was therefore to examine consumers' awareness of Lidl's ESG reports and CSR activities. The survey results show that respondents are familiar with Lidl's various CSR activities, and the main communication channels, such as advertising or in-store advertisements, are more familiar to consumers. A not too surprising finding is that only a small part of the respondents is familiar with Lidl's non-financial reports. However, if they are familiar, they perceive the company as more transparent. Regarding the relationship between age and the perception of Lidl as a transparent company, a dependence was confirmed.

The results of our study can serve as a basis for further research. This should primarily focus on why consumers who consider CSR activities beneficial are not familiar with the company's reports and only know those that are promoted, e.g. through advertising.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** Data sharing is not applicable to this article.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Alhouti, S., Wright, S. A., & Baker, T. L. (2021). Customers need to relate: The conditional warm glow effect of CSR on negative customer experiences. *Journal of Business Research*, 124, 240-253. <https://doi.org/10.1016/j.jbusres.2020.11.047>
- Arvidsson, S., & Dumay, J. (2022). Corporate ESG reporting quantity, quality and performance: Where to now for environmental policy and practice? *Business Strategy and the Environment*, 31(3), 1091-1110. <https://doi.org/10.1002/bse.2937>
- Berg, F., Kolbel, J. F., & Rigobon, R. (2022). Aggregate confusion: the divergence of ESG ratings. *Review of Finance*, 26(6), 1315–1344. <https://doi.org/doi:10.1093/rof/rfac033>
- Boccia, F., Manzo, R. M., & Covino, D. (2019). Consumer behavior and corporate social responsibility: An evaluation by a choice experiment. *Corporate Social Responsibility and Environmental Management*, 26(1), 97-105. <https://doi.org/10.1002/csr.1661>
- Chen, S., & Fan, M., (2024). ESG ratings and corporate success: analyzing the environmental governance impact on Chinese companies' performance. *Frontiers in energy research*, 12, 1371616. <https://doi.org/10.3389/fenrg.2024.1371616>
- Davis, K. and Blomstrom, R.L. (1975) *Business and Society: Environment and Responsibility*. McGraw-Hill, New York.

- Enz, C., Skodova Parmova, D., & Wolf, P. (2021). Importance of ethical competence for the sales management of small and medium-sized financial sales organisations. *DETUROPE – The Central European Journal of Regional Development and Tourism*, 13(1), 121-152. <https://doi.org/0.32725/det.2021.007>
- Estanyol, E., Lalueza, F., & Compte-Pujol, M. (2025). Comunicar la responsabilidad social corporativa en la era de la desinformación: Una aproximación a las agencias de relaciones públicas en España. *Palabra Clave*, 28(1), e28s114. <https://doi.org/10.5294/pacla.2025.28.s1>
- Hu, H.-H. S. (2025). CSR Communications: The Effects of CSR Activities and Communication Channels. *Journal of Consumer Behaviour*, 24(4), 1839–1853. <https://doi.org/10.1002/cb.2494>
- Isa, S. M. (2012). Corporate Social Responsibility: What can we Learn from the Stakeholders? In *International Congress on Interdisciplinary Business and Social Sciences*, 65, 327-337. <https://doi.org/10.1016/j.sbspro.2012.11.130>
- Isack, M., & Aschauer, E. (2025). The Role of CSR Report Assurance and ESG Rating in Bank Manager's Judgement on ESG Lending Decisions. *International Journal of Auditing*, 29(2), 280-304. <https://doi.org/10.1111/ijau.12369>
- Jambor, A., & Zanoz, A. (2023). The Diversity of Environmental, Social, and Governance Aspects in Sustainability: A Systematic Literature Review. *Sustainability*, 15(18), 13958. <https://doi.org/10.3390/su151813958>
- Kang, Y. J., Slaten, T., & Choi, W. J. (2021). Felt betrayed or resisted? The impact of pre-crisis corporate social responsibility reputation on post-crisis consumer reactions and retaliatory behavioral intentions. *Corporate Social Responsibility and Environmental Management*, 28(4), 511-524. <https://doi.org/10.1002/csr.2067>
- Kazmierczak, M. (2022). A literature review on the difference between CSR and ESG. *Scientific Papers of Silesian University of Technology-Organization and Management Series*. 162, 275-289. <https://doi.org/10.29119/1641-3466.2022.162.16>
- Lidl Slovenska republika. (2024). *Sme za ferovnu hru!* [LinkedIn post]. [https://www.linkedin.com/posts/lidl-slovenska-republika\\_fondpretransparentneslovensko-lidl-zodpovednost-activity-7196053913089789953-6HVt](https://www.linkedin.com/posts/lidl-slovenska-republika_fondpretransparentneslovensko-lidl-zodpovednost-activity-7196053913089789953-6HVt)
- Lidl Slovenska republika. (2025). *Spolocenska zodpovednost*. <https://www.spolocenskazodpovednost.sk/aktualita/vedenie-dialogu/lidl-akademia>
- Lim, J. S., & Greenwood, C. A. (2017). Communicating corporate social responsibility (CSR): Stakeholder responsiveness and engagement strategy to achieve CSR goals. *Public Relations Review*, 43(4), 768-776. <https://doi.org/10.1016/j.pubrev.2017.06.007>
- McGuire, J. B., Sundgren, A., & Schneeweis, T. (1988). Corporate social responsibility and firm financial performance. *Academy of management Journal*, 31(4), 854-872. <https://doi.org/10.2307/256342>
- Petery, K. (2023). *ESG (Environmental, Social, & Governance)*. <https://corporatefinanceinstitute.com/resources/esg/esg-environmental-social-governance/>
- Rozsa, Z., Belas, J. Jr., Khan, K. A., & Zvarikova, K. (2021). Corporate Social Responsibility and essential factors of personnel risk management in SMEs. *Polish Journal of Management Studies*, 23(2), 449-463. <https://doi.org/10.17512/pjms.2021.23.2.27>
- Sareen, M., & Mahajan, R. (2025). Prioritization of Critical Success Determinants in Corporate Social Responsibility Communication on Social Media: A Best-Worst Method Analysis. *Business Strategy and Development*, 8(1), e70089. <https://doi.org/10.1002/bsd2.70089>
- Spaniol, M. J., Danilova-Jensen, E., Nielsen, M., Rosdahl, C. G., & Schmidt, C. J. (2024). Defining greenwashing: A concept analysis. *Sustainability*, 16(20), 9055. <https://doi.org/10.3390/su16209055>
- Vveinhardt, J., & Sroka, W. (2020). Mobbing and corporate social responsibility: Does the status of the organisation guarantee employee wellbeing and intentions to stay in the job? *Oeconomica Copernicana*, 11(4), 743-778. <https://doi.org/10.24136/oc.2020.030>
- Wang, L., & Dong, L. (2025). The interactive effects of strategy communication and report integration on investors' reactions to corporate social responsibility measures. *Advances in Accounting*, 68, 100784. <https://doi.org/10.1016/j.adiac.2024.100784>
- Zvarikova, K. (2023). *Spolocensky zodpovedne podnikanie*. EDIS-Vydavateľstvo Zilinskej univerzity.

## ASSESSING FINANCIAL STABILITY THROUGH DEBT INDICATORS IN THE SLOVAK ENGINEERING SECTOR

Erika Kovalova<sup>1,a,\*</sup> and Janka Grofcikova<sup>2,b</sup>

<sup>1</sup>University of Zilina, Faculty of Operation and Economics of Transport and Communications,  
Univerzitna 1, 010 26 Zilina, Slovakia

<sup>2</sup>Matej Bel University in Banska Bystrica, Faculty of Economics, Tajovskeho 10, 975 90 Banska  
Bystrica

<sup>a</sup>erika.kovalova@uniza.sk, <sup>b</sup>janka.grofcikova@umb.sk

\*Corresponding author

**Cite as:** Kovalova, E., Grofcikova, J. (2025). *Assessing financial stability through debt indicators in the Slovak engineering sector*, *Ekonomicko-manazerske spektrum*, 19(1), 129-141.

**Available at:** [dx.doi.org/10.26552/ems.2025.1.129-141](https://dx.doi.org/10.26552/ems.2025.1.129-141)

---

*Received: 20 March 2025; Received in revised form: 18 May 2025; Accepted: 4 June 2025; Available online: 30 June 2025*

### **Abstract:**

**Research background:** In the context of increasing economic volatility and competitive pressure, the financial stability of industrial enterprises has become a critical area of analysis. The mechanical engineering sector, as a capital-intensive industry, is particularly sensitive to the structure and level of indebtedness. Financial analysis, especially debt analysis, plays a central role in identifying the financial health of enterprises. Appropriate capital structure enhances long-term sustainability, while excessive reliance on external financing may increase insolvency risk. The Slovak mechanical engineering sector, although economically significant, remains underexamined in this context.

**Purpose of the article:** This study aims to assess the financial stability of enterprises in the Slovak mechanical engineering sector by analyzing indebtedness indicators and identifying differences based on company size and legal form. It further seeks to evaluate compliance with selected financial principles such as the golden balance and parity rules.

**Methods:** The research is based on secondary data obtained from the Moody's database for the period 2019–2023, covering enterprises under NACE section C25, C28, C29, C30. Descriptive statistics and non-parametric methods, specifically the Kruskal–Wallis test, were used to examine the influence of size and legal form on six key debt indicators: total indebtedness, credit indebtedness, debt-to-equity ratio, interest coverage, financial leverage, and insolvency.

**Findings & Value added:** The average total debt remained below the 70% threshold, indicating moderate indebtedness. Statistically significant differences were found in four out of six indicators depending on company size, while legal form influenced only credit debt. The sector exhibited consistent undercapitalization and partial non-compliance with the golden balance rule, raising concerns about long-term financial sustainability. This article contributes to the existing literature by providing sector-specific evidence on indebtedness in the Slovak engineering industry. It offers practical recommendations for improving financial management practices, especially in terms of capital structure optimization, risk mitigation, and strategic planning. The findings are relevant for financial analysts, company managers, and policymakers focused on industrial development and economic resilience.

**Keywords:** financial analysis; indebtedness; engineering sector; capital structure; financial stability

**JEL Classification:** C12; D24; G32; L60; M21

## 1. Introduction

It is very rare for a company to finance all its activities solely from its own resources; thus, in the real economy, companies inevitably incur debt. The term indebtedness refers to the fact that a company uses external sources—namely debt—to finance its assets and is therefore leveraged. Similarly, exclusive reliance on equity financing is not feasible, as companies lacking sufficient equity would typically be unable to obtain credit (Uradnicek et al., 2016). One of the primary tasks of financial management is to determine the total required capital and subsequently select appropriate sources for its acquisition. The objective of indebtedness analysis is to identify the optimal balance between equity and debt financing, thereby establishing an appropriate capital structure (Valaskova et al., 2023).

Indebtedness, or the proper configuration of capital structure, significantly affects a company's financial stability. A high proportion of equity capital renders a company more independent and stable, as it does not have to repay interest on borrowed funds. Such companies are also more attractive to investors, given that a lower level of indebtedness provides greater potential for growth. Conversely, a low equity ratio implies financial vulnerability and increases uncertainty for creditors (Zalai et al., 2016).

Generally, equity capital is more expensive than debt capital. Shareholders expect returns on their investments that exceed typical bank deposit yields. Dividends are usually higher than loan interest payments, which is why equity is considered costlier. Furthermore, dividends are paid from net profit after taxation, which further increases their cost to the company (Kliestik et al., 2020).

The economic environment and the market are constantly evolving, making it necessary to apply new methods for calculations of various financial aspects. This is why financial analysis plays an important role in supporting the financial management of companies (Karas and Reznakova, 2020). The necessity of financial analysis is also emphasized by Du Jardin (2025), who argue that relying solely on financial analysis based on past results is no longer sufficient; it should be supplemented with non-financial measurement methods. They analyzed methods of financial performance and found that companies typically prepare financial analyses independently and regularly, using internal systems, while determining which indicators are most applied (Kliestik et al., 2019; Valaskova et al., 2020).

It is crucial for companies to prepare their financial statements in a way that allows comparison over time, ensuring consistent accounting procedures. Durica et al. (2019) highlighted important information about financial analysis methods, sources, and databases within the Slovak business context. One such database is CRIF – Slovak Credit Bureau, which offers business, consumer, and marketing information. However, the accessibility of this database is limited, as it is not affordable for all interested parties. The study concluded that well-organized information and data sources are essential for effective financial analysis (Durica and Frnda, 2021).

A comprehensive understanding of a company's current financial position is essential for effective management. Financial analysis serves as a fundamental tool to evaluate the overall financial health of an enterprise, providing critical insights that support strategic decision-making and planning processes. Financial analysis of indebtedness is especially important, as it offers a detailed view of the company's capital structure and enables assessment of the

balance between equity and external financing sources (Niessner et al., 2022; Valaskova et al., 2018).

The origins of financial analysis trace back to the advent of monetary systems. Over time, the methods and techniques have evolved in response to prevailing economic conditions. While the structure and depth of analysis have changed significantly, the fundamental principles and objectives have remained consistent (Slosarova and Blahusiakova, 2017). The modern form of financial analysis, as recognized today, originated in the United States. In Slovakia, the term gained wider relevance only after 1989, concurrent with the transition to a market-oriented economy (Kovacova et al., 2019a).

Financial and economic analysis is a core component of financial management, providing essential feedback on company performance across various domains. It enables managers to assess whether strategic objectives have been met and to identify areas requiring corrective actions or risk mitigation (Baculikova and Sochulakova, 2016).

Until 1992, the term "economic activity analysis" was more commonly used in Slovakia in relation to financial assessment. These analyses reflected conditions of the centrally planned economy and were based on mandatory indicators. Although some methodological elements overlapped with modern financial analysis, the two approaches are not directly comparable due to fundamental differences in economic systems. Today, the terms financial analysis and financial-economic analysis are widely accepted and used in Slovakia (Valaskova et al., 2017).

Financial analysis is predominantly applied within business enterprises and is generally understood as a comprehensive assessment of a firm's financial position. Temporally, it is divided into ex post and ex ante analysis: ex post analysis evaluates past financial performance, while ex ante focuses on current data to forecast future financial conditions (Durica et al., 2023).

The primary aim of financial analysis is to assess a company's financial health, identify potential weaknesses that could lead to future difficulties, and highlight strengths that can be leveraged for sustainable development (Kovacova and Kliestik, 2017).

The functions and objectives of financial analysis stem from the needs of financial decision-making, which is central to corporate financial management. Effective decision-making requires thorough understanding of managed phenomena, their interrelationships, accurate evaluation of data, and careful consideration of risks and uncertainties.

The purpose and methodology of financial analysis vary depending on several factors. To achieve accurate and actionable results, certain methodological principles must be followed, including ensuring qualitative attributes of financial information such as relevance, reliability, and comparability—essential for professional analysis (Elexa, 2015).

The relevance of financial analysis results largely depends on the user's perspective and relationship to the analyzed entity. Users are generally classified into three groups: internal users, equity stakeholders, and external third parties (Kovacova et al., 2019b). Blahusiakova (2020) distinguishes two primary groups: internal and external users, based on access to source data that underpin financial indicators.

Data forms the critical foundation of financial analysis. Slosarova and Blahusiakova (2017) assert that primary sources of information for corporate financial analysis are financial accounting statements, with the balance sheet, income statement, and notes being particularly important in Slovakia.

Methodologies in financial analysis range from basic mathematical techniques to complex analytical models, which have become increasingly standardized over time (Jencova, 2020). Slosarova and Blahusiakova (2017) categorize these methods into basic (elementary) and advanced financial analysis techniques.

Among elementary methods, ratio analysis is one of the most frequently used tools. It offers insights into a company's historical financial condition by examining relationships between financial statement items. Typical ratio categories include liquidity, activity, profitability, and indebtedness (Karas, 2022).

Indebtedness analysis focuses on a firm's long-term solvency and ability to meet obligations from external sources. The optimal ratio of external financing depends on business type and the level of risk acceptable to creditors and shareholders (Gregova et al., 2020).

Valaskova et al. (2020) emphasize that debt ratios are essential for monitoring the structure of corporate financial resources. The balance between equity and debt financing significantly affects financial stability.

According to Gurcik (2018) and Jencova (2020), key indicators of indebtedness include total debt ratio, self-financing ratio, financial leverage, credit indebtedness, and interest coverage ratio. Advanced analytical methods aim to provide a holistic view that helps identify early warning signs of potential insolvency (Horvathova et al., 2023). Economic statistics play a crucial role in quantifying economic phenomena under specific conditions, representing economic reality through measurable indicators (Duricova et al., 2025).

## **2. Methodology**

This section outlines the methodological framework applied in the analysis of corporate indebtedness within the Slovak mechanical engineering sector. The research is based on quantitative financial analysis techniques supported by the statistical evaluation of secondary data. The primary data source was the Moody's database, covering the period 2019–2023. The sample includes companies classified under NACE division C (Manufacturing), specifically section C28 – Manufacture of machinery and equipment not elsewhere classified.

The primary objective of the study was to assess the level of indebtedness and financial autonomy among enterprises operating in this sector. The analysis focused on key financial indicators:

- total debt ratio – proportion of total liabilities to total assets;
- equity ratio – proportion of equity to total assets;
- financial leverage – ratio of total liabilities to equity;
- interest coverage ratio – calculated as EBIT divided by interest expenses.

For each indicator, descriptive statistics were computed, including mean, standard deviation, median, and quartile distribution. Firms were further segmented according to:

- company size: micro, small, medium, and large enterprises;
- legal form: limited liability companies (Ltd.), joint-stock companies (JSC), and others;
- geographic region: administrative divisions within Slovakia.

Data processing and analysis were conducted using Microsoft Excel and SPSS software. Descriptive statistics and cross-tabulation were employed to examine structural patterns. Subsequently, a nonparametric analysis of variance (ANOVA) using the Kruskal–Wallis test was applied in SPSS due to the non-normal distribution of the dataset, which invalidates parametric testing (Teplicka, 2016).

The objective was to assess whether selected debt-related indicators—total debt ratio, credit debt, debt-to-equity ratio, interest coverage, financial leverage, and insolvency coverage—differ significantly across enterprise size categories (small, medium-sized, large, and very large) (Maros, 2024).

The hypotheses tested were:

$H_0$  (null hypothesis): *Enterprise size has no statistically significant effect on the selected debt indicators.*

$H_1$  (alternative hypothesis): *Enterprise size has a statistically significant effect on the selected debt indicators.*

The significance level was set at  $\alpha = 0.05$ .

The Kruskal–Wallis test was also used to evaluate whether the legal form of enterprises influences variability in indebtedness indicators (Titko et al., 2021). This analysis examined whether statistically significant differences exist in total indebtedness, credit indebtedness, debt-to-equity ratio, interest coverage ratio, financial leverage, and insolvency coverage, based on legal form—limited liability companies (Ltd.) versus joint-stock companies (JSC).

Hypotheses for this test were:

$H_0$  (null hypothesis): *Legal form has no statistically significant effect on the selected indicators of indebtedness.*

$H_1$  (alternative hypothesis): *Legal form has a statistically significant effect on the selected indicators of indebtedness.*

The significance level was again set at  $\alpha = 0.05$ .

#### Overview of the Slovak Mechanical Engineering Sector

The mechanical engineering industry represents a foundational pillar of the Slovak economy, playing a central role in ensuring long-term macroeconomic stability. The sector is characterized by a strong historical legacy and holds a prominent position within the national industrial structure. Its importance is reflected not only in its contribution to GDP and foreign trade but also in employment and labor market performance (SARIO, 2025).

According to the NACE statistical classification, the mechanical engineering sector comprises:

- NACE 25 – Manufacture of fabricated metal products, except machinery and equipment;
- NACE 28 – Manufacture of machinery and equipment n.e.c.;
- NACE 29 – Manufacture of motor vehicles, trailers, and semi-trailers;
- NACE 30 – Manufacture of other transport equipment (SK NACE, 2025).

Within the sector, NACE 29 dominates with approximately 72.10% share, followed by NACE 28 with 14.40%, NACE 25 with 12%, and NACE 30 with 1.5%.

Mechanical engineering enterprises are geographically dispersed throughout Slovakia. Regions with strong industrial traditions largely result from the historical presence of large engineering facilities. There is a significant interconnection between mechanical engineering and the automotive industry, the latter being the main driver of industrial investment in Slovakia.

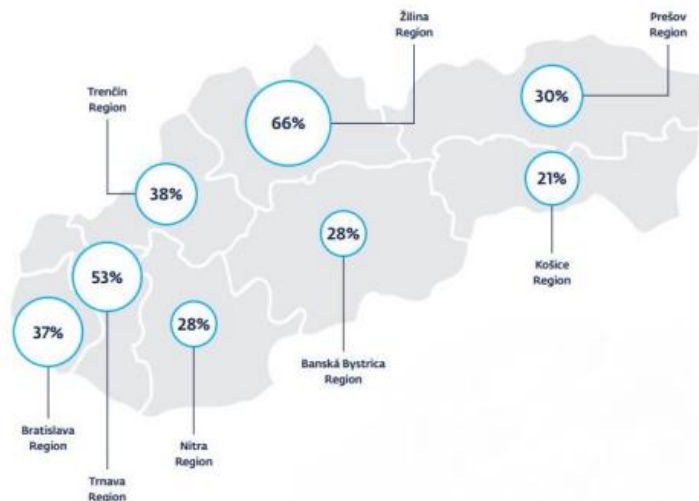
The automotive industry — the dominant sector of the Slovak economy — is primarily concentrated in the western regions, with major plants such as PSA Peugeot–Citroen (Trnava), Kia Motors (Zilina), and Volkswagen (Bratislava). These contribute substantially to passenger vehicle production. Additionally, Komarno hosts internationally recognized production of ships and boats, which is classified under broader automotive manufacturing.

Despite its strengths, the heavy specialization and investment concentration in the automotive sector create vulnerabilities. Slovakia ranks among the global leaders in vehicles produced per capita, exposing the economy to risks from external shocks. A global downturn or reduced vehicle demand could trigger increased unemployment and macroeconomic instability.

The Slovak mechanical engineering sector also includes production of rolling stock (locomotives, railcars) at plants in Martin, Trnava, ZOS Vrútky, and Tatrávagonka Poprad.

Alongside automotive growth, the metalworking subsector has gained importance as a key industrial component, with enterprises engaging in advanced machining and metal-processing technologies. Figure 1 (SARIO, 2025) illustrates the regional contribution of enterprises to the sector's overall output, highlighting spatial disparities and industrial concentration within Slovakia.

*Figure 1: The regional share of enterprises in the gross output of the engineering industry*



*Source: own processing based on SARIO (2025)*

### 3. Results

Debt indicators represent essential tools in financial analysis, providing a detailed insight into a company's capital structure. Indebtedness should not be viewed inherently as a negative phenomenon; when managed effectively, a higher degree of financial leverage can lead to increased profitability and, consequently, higher market valuation. In essence, debt reflects the extent to which a company's assets are financed through borrowed capital. Since relying solely on either equity or debt is neither feasible nor optimal in the long run, one of the primary tasks of financial management is to determine the appropriate volume and optimal structure of capital. Therefore, debt analysis focuses on identifying the ideal ratio between equity and liabilities, which significantly affects a company's financial health and long-term sustainability.

The analysis of total debt and self-financing ratios helps to identify potential risks associated with asset financing and is thus essential in evaluating a company's financial stability.

Total debt indicates the extent to which a company's assets are financed by external capital and

serves as a credit risk indicator. It is one of the most important financial stability metrics and is frequently monitored. The generally recommended threshold is up to 50%, with an upper acceptable limit of 70%. In 2023, the average total debt ratio in the Slovak mechanical engineering sector reached 58.61%, meaning that approximately 0.59€ of every 1€ in assets was financed by debt. The highest recorded value occurred in 2019 at 61%. Despite fluctuations throughout the observed period, the indicator remained within acceptable bounds. A year-over-year decrease of 1.86% was recorded from 2022 to 2023.

The self-financing ratio reflects a company's financial independence and stability. Despite exhibiting fluctuations during the analyzed period, the indicator remained within recommended values and never dropped below 30%, indicating an adequate level of internal financing. This

reduced dependency on external sources and enhanced resilience to economic shocks. The best performance was observed in 2023, when the average self-financing ratio reached 41.39%, representing an increase of 2.76% compared to the previous year. The lowest values were recorded between 2019 and 2021, likely due to the impacts of the COVID-19 pandemic, with the lowest average in 2019 at 38.36%.

Short-term indebtedness reflects the degree to which a company uses liabilities due within one year. During the observed period, the indicator exhibited a fluctuating trend. The lowest value was recorded in 2023, when approximately 0.43€ of every 1€ in assets was financed through short-term debt, representing a year-over-year decline of 3.75% or an absolute change of 1.63. The highest level of short-term indebtedness was observed in 2019, at 0.44€ per 1€ of assets. These findings indicate that companies in the mechanical engineering sector tend to rely more on short-term financing, potentially increasing their exposure to liquidity risk.

Long-term indebtedness, in contrast to short-term debt, represents a more stable and favorable method of financing assets over the long term. This indicator, similarly, to short-term debt, can only assume non-negative values (Cisko and Kliestik, 2013; Camska and Klecka, 2020). In 2023, the average long-term debt ratio in the mechanical engineering sector reached 16.74%, indicating that 0.17€ of every 1€ in assets was financed by long-term liabilities. This represents an increase of 3.20% compared to the previous year. The highest value during the analyzed period was recorded in 2020 at 17.85%. Compared to short-term debt, long-term indebtedness showed greater stability, suggesting a balanced and sustainable capital structure across the sector.

The coverage of non-current assets (long-term assets) reflects adherence to the golden balance rule. The value of this indicator among mechanical engineering enterprises ranged from 0.49 to 0.93 during the analyzed period. In 2023, the coverage of non-current assets stood at 0.52, representing a decrease of almost 43% compared to the preceding year. In all analyzed years, the indicator remained below the threshold of 1, indicating undercapitalization. Non-compliance with the golden balance rule implies that long-term assets were not fully financed with long-term sources, suggesting a riskier financing structure in the sector (Karas and Reznakova, 2021).

In the final stage of the analysis, attention is directed toward evaluating the golden balance rule, the golden parity rule, and the golden risk equalization rule. These financial principles constitute fundamental guidelines for maintaining financial stability and ensuring an optimal equilibrium between equity and debt financing.

The golden balance rule posits that the maturity structure of a company's assets should correspond to the maturity structure of its financing sources. Specifically, long-term assets should be financed through long-term capital, while short-term assets should be financed using short-term resources. In 2023, the ratio of short-term liabilities to current assets reached 0.97, indicating that 97% of current assets were covered by short-term funding. Compared to the previous period, this represents a decline of approximately 1%. These findings suggest that enterprises within the mechanical engineering sector should pursue improved alignment between asset structure and financing sources to enhance liquidity and minimize refinancing risk.

The golden parity rule asserts that the value of equity should not be lower than the value of fixed assets. This reflects a company's ability to finance long-term investments using its own capital. Throughout the analyzed period, the value of this indicator remained below 1.0, indicating consistent non-compliance with the rule. The most favorable outcome was observed in 2023, when the ratio reached 0.88, representing a 5.89% increase relative to the prior year. Conversely, the weakest performance occurred in 2019, with a value of 0.68. Persistent

violation of this principle suggests structural undercapitalization, which may compromise the long-term financial resilience of enterprises. Accordingly, firms in the engineering sector should prioritize the strengthening of equity capital to mitigate long-term financial risk.

The golden risk equalization rule stipulates that a company's equity should exceed its external liabilities, thereby signifying a stable financial position. During the observed period, the value of this indicator consistently exceeded 1.0, indicating that own resources surpassed external liabilities across all years—a highly favorable outcome. The strongest performance was recorded in 2023, with a ratio of 1.31, denoting that equity capital exceeded external liabilities by 31%. This represents a year-over-year increase of 10.58%. These results indicate a robust capital structure and suggest that engineering enterprises, on average, maintained a sound level of financial autonomy during the period under review (Karas and Reznakova, 2023).

This section summarizes the key empirical findings derived from the applied methodological framework, including the data collection, analysis, and verification of hypotheses related to the capital structure and financial stability of enterprises operating in the mechanical engineering sector.

Based on the comparison between the p-values and the predefined significance level ( $\alpha = 0.05$ ), the results of the Kruskal–Wallis test indicate that for the indicators interest coverage and insolvency, the p-values (0.630 and 0.149, respectively) exceed the alpha threshold. Therefore, we fail to reject the null hypothesis ( $H_0$ ) and conclude that the size of the enterprise does not have a statistically significant effect on these two indebtedness indicators.

In contrast, for the remaining indicators—total indebtedness, credit indebtedness, debt-to-equity ratio, and financial leverage—the p-values are below 0.05, indicating statistically significant differences between enterprise size categories. Consequently, the null hypothesis is rejected in favor of the alternative hypothesis ( $H_1$ ), suggesting that enterprise size significantly influences these aspects of indebtedness. These results are summarized in Table 1.

*Table 1: Debt indicators by enterprise size*

| Indicator            | P-value | Hypothesis test result            |
|----------------------|---------|-----------------------------------|
| Total indebtedness   | 0.000   | Reject the null hypothesis        |
| Credit indebtedness  | 0.047   | Reject the null hypothesis        |
| Debt-to-equity ratio | 0.000   | Reject the null hypothesis        |
| Interest coverage    | 0.630   | Do not reject the null hypothesis |
| Financial leverage   | 0.000   | Reject the null hypothesis        |
| Insolvency           | 0.149   | Do not reject the null hypothesis |

*Source: own processing*

These results suggest that enterprise size plays a significant role in determining the level and structure of corporate indebtedness, particularly with respect to total debt, credit debt, capital structure (debt-to-equity), and leverage. However, no significant relationship was found between enterprise size and the ability to cover interest obligations or mitigate insolvency risk.

Based on the comparison between the p-values and the predetermined significance level ( $\alpha = 0.05$ ), the results indicate that only the credit debt indicator exhibits a statistically significant difference with respect to the legal form of enterprises. Specifically, the p-value for this indicator is 0.010, which is below the  $\alpha$  threshold. Consequently, the null hypothesis ( $H_0$ ) is rejected in favor of the alternative hypothesis ( $H_1$ ), indicating that the legal form of the enterprise has a significant effect on credit indebtedness. These findings are presented in Table 2.

For all other analyzed indicators—total debt, debt-to-equity ratio, interest coverage ratio, financial leverage, and insolvency coverage—the p-values exceed the significance threshold,

Table 2: Debt indicators by legal form of enterprises

| Indicator            | P-value | Hypothesis test result            |
|----------------------|---------|-----------------------------------|
| Total indebtedness   | 0.324   | Do not reject the null hypothesis |
| Credit indebtedness  | 0.010   | Reject the null hypothesis        |
| Debt-to-equity ratio | 0.324   | Do not reject the null hypothesis |
| Interest coverage    | 0.723   | Do not reject the null hypothesis |
| Financial leverage   | 0.324   | Do not reject the null hypothesis |
| Insolvency           | 0.713   | Do not reject the null hypothesis |

Source: own processing

leading to the retention of the null hypothesis. This suggests that the legal form of enterprises does not significantly influence these debt-related indicators.

## 4. Discussion

The analysis of indebtedness within the Slovak engineering industry revealed that the overall debt ratio of enterprises did not exceed the recommended threshold of 70%, indicating a financially sound level of indebtedness in this sector. From an investor's perspective, this is considered favorable, as there is generally greater interest in enterprises that maintain lower levels of financial leverage.

The self-financing ratio remained above 30% throughout the observed period, which suggests that enterprises in the engineering industry can sustain their business operations through internally generated funds.

Short-term debt ranged from 41.87% to 44.10%, indicating a high reliance on short-term liabilities to finance operations. In contrast, long-term debt varied between 8.60% and 9.23%, which is deemed acceptable and reflects a stable long-term financial base with minimal additional financing costs.

The credit debt ratio, also within the range of 8.60% to 9.23%, demonstrates that enterprises in this sector do not heavily rely on bank financing. The interest coverage ratio exhibited considerable fluctuation, ranging from 28.04 to 222.85. The sharp increase in this indicator in the final year of the analyzed period suggests that engineering enterprises possess a strong ability to cover interest expenses, possibly due to post-pandemic recovery. The lowest values were recorded during 2020–2021, likely reflecting the financial strain caused by the COVID-19 pandemic. Interest burden ranged from 3.75% to 15.69%, while the debt-to-equity ratio results indicate that enterprises in this sector generally maintain a healthy balance between equity and debt financing.

However, the fixed asset coverage ratio implies that some firms may face challenges in financing their non-current assets, raising concerns regarding the alignment of asset structure and capital sources. The cash flow debt ratio ranged significantly from -24.78 to 27.28, with values in 2019 and 2022 indicating that companies were unable to service their debt obligations from operational cash flows. The results for the financial leverage indicator suggest that enterprises in this industry utilize debt capital to finance their operations, though within acceptable limits.

The financial independence ratio, ranging from 1.04 to 1.18, suggests that companies are generally capable of covering liabilities using internal resources. Furthermore, the capital adequacy ratio ranged between 2.33 and 4.10, indicating a state of overcapitalization within the sector.

The insolvency ratio, recorded between 5.81 and 6.92, points to primary insolvency risks, i.e., companies may be unable to settle their obligations in a timely manner. However, this finding requires further validation through a liquidity analysis.

The application of statistical methods confirmed that selected debt indicators are significantly influenced by enterprise size, legal form, and NACE classification. Specifically:

(i) firm size significantly affects the interest coverage and insolvency indicators; (ii) legal form has a statistically significant influence on credit debt; (iii) the NACE classification impacts the insolvency indicator; and (iv) for the remaining debt indicators, no statistically significant relationship was identified with enterprise size or legal form.

Overall, the financial analysis focused on indebtedness suggests that the Slovak engineering industry maintains a relatively stable financial condition. Enterprises generally preserve a healthy level of indebtedness and are capable of financing operations through equity capital.

Nonetheless, certain areas warrant attention, particularly regarding short-term debt levels, fixed asset coverage, capital adequacy, and insolvency risks. It is advisable for engineering enterprises to improve liquidity, which can help mitigate insolvency risks. This could be achieved through working capital optimization.

Moreover, strict adherence to the golden balance rule is crucial, as it serves as a key instrument for ensuring financial stability. This implies maintaining an appropriate proportion between equity and debt capital. Enterprises should aim to increase the share of equity in their capital structure.

In general, engineering firms should place greater emphasis on: (i) financial planning; (ii) the quality of financial analysis; (iii) continuous education and reskilling of employees; and (iv) innovation.

Long-term financial planning enhances the ability to respond effectively to economic fluctuations. High-quality financial analysis provides valuable insight into the firm's financial position, facilitating informed decision-making and strategic foresight.

Ongoing training and upskilling are essential considering technological and innovative advancements, which may affect workforce qualifications. Innovation plays a critical role by enabling process optimization, which can lead to cost reductions, increased competitiveness, new business opportunities, and higher-quality products and services.

## **5. Conclusions**

The primary objective of this study was to identify, evaluate, and compare key financial parameters of enterprises operating within a specific segment of the national economy—namely, the engineering industry—with a particular focus on debt-related indicators. In addition to conducting a detailed financial assessment, the research also aimed to propose actionable recommendations to enhance the financial stability and long-term sustainability of the analyzed enterprises.

The study first elaborated on the theoretical foundations of financial analysis, emphasizing its methodologies, tools, and relevance for assessing corporate financial health. Special attention was given to the analysis of indebtedness, including the interpretation of core debt-related ratios. These conceptual frameworks were then applied in the empirical part of the research, which utilized a dataset of enterprises from the engineering sector, classified according to the NACE statistical framework. A set of key debt indicators was used to conduct a comprehensive evaluation of the sector's financial position.

The findings of the analysis revealed several critical insights. While the sector demonstrates a relatively stable level of overall indebtedness—remaining below the commonly accepted threshold—the analysis also uncovered risk-prone areas. Notably, issues related to short-term debt exposure, fixed asset coverage, and primary insolvency were identified as potential threats to financial resilience. The observed fluctuations in credit indebtedness and interest coverage

further highlight the variability in financial health among enterprises, some of which may face challenges in maintaining adequate liquidity and solvency, especially during adverse economic conditions.

Furthermore, the statistical analysis confirmed that debt indicators are not uniform across all enterprises. Variations were found based on firm size, legal structure, and sectoral classification. This suggests that tailored financial strategies, sensitive to firm-specific characteristics, are essential for effective financial management and risk mitigation.

Based on these results, the study proposes a series of targeted measures aimed at improving financial stability in the engineering sector. These include enhancing liquidity management through working capital optimization, reinforcing equity capital to ensure a healthier capital structure, and adhering to fundamental principles of financial balance such as the golden balance rule. Additionally, the promotion of long-term financial planning, continuous professional development, and innovation adoption is emphasized as crucial for reinforcing the sector's resilience against external shocks.

In conclusion, the contribution offers both theoretical enrichment and practical value. The findings serve as a relevant reference point for financial managers, investors, and policymakers interested in strengthening the economic performance and sustainability of enterprises in capital-intensive industries. Future research should aim to extend this analysis across different time periods or economic sectors to validate the generalizability of the findings and refine the proposed recommendations.

**Author contributions:** All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Funding:** This research received no external funding.

**Data Availability Statement:** Data sharing is not applicable to this article

**Acknowledgments:** This research was financially supported by the Slovak Research and Development Agency Grant VEGA 1/0494/24: Metamorphoses and causalities of indebtedness, liquidity and solvency of companies in the context of the global environment.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Baculikova, N., & Sochulakova, J. (2016). *Financno-ekonomicka analyza*. Trencin: FSEV TnUAD.
- Blahusiakova, M. (2020). *Vyvoj financneho zdravia podnikov vybranych odvetvi v Slovenskej republike v kontexte pandémie COVID-19* (1st ed.). Bratislava: Letra Edu.
- Camska, D., & Klecka, J. (2020). Comparison of prediction models applied in economic recession and expansion. *Journal of Risk and Financial Management*, 13(3), 52. <https://doi.org/10.3390/jrfm13030052>
- Cisko, S., & Klietstik, T. (2013). *Financny manazment podniku II*. Zilina: EDIS.
- Du Jardin, P. (2025). Designing ensemble-based models using neural networks and temporal financial profiles to forecast firms' financial failure. *Computational Economics*, 65(1), 149-209. <https://doi.org/10.1007/s10614-024-10579-4>
- Durica, M., & Frnda, J. (2021). *Using data mining methods to predict financial distress*. Zilina: EDIS.
- Durica, M., Frnda, J., & Svabova, L. (2019). Decision tree based model of business failure prediction for Polish companies. *Oeconomica Copernicana*, 10(3), 453-469. <https://doi.org/10.24136/oc.2019.022>
- Durica, M., Frnda, J., & Svabova, L. (2023). Artificial neural network and decision tree-based modelling of non-prosperity of companies. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 18(4), 1105–1131. <https://doi.org/10.24136/eq.2023.035>

- Duricova, L., Kovalova, E., Gazdikova, J., & Hamranova, M. (2025). Refining the best-performing V4 financial distress prediction models: Coefficient re-estimation for crisis periods. *Applied Sciences*, 15(6), 2956. <https://doi.org/10.3390/app15062956>
- Elexa, L. (2015). *Business financial analysis* (1st ed.). Banska Bystrica: Vydavateľstvo Mateja Bela v Banskej Bystrici Belianum.
- Gregova, E., Valaskova, K., Adamko, P., Tumpach, M., & Jaros, J. (2020). Predicting financial distress of Slovak enterprises: Comparison of selected traditional and learning algorithms methods. *Sustainability*, 12(10), 3954. <https://doi.org/10.3390/su12103954>
- Gurcik, L. (2018). *Podnikatelska analyza a kontroling* (1st ed.). Nitra: Slovenska polnohospodarska univerzita v Nitre.
- Horvathova, J., Mokrisova, M., & Baca, M. (2023). Bankruptcy prediction for sustainability of businesses: The application of graph theoretical modeling. *Mathematics*, 11(24), 4966. <https://doi.org/10.3390/math11244966>
- Jencova, S. (2020). *Financno-ekonomicka analyza podnikatelskych subjektov* (4th revised and expanded ed.). Presov: Bookman.
- Karas, M. (2022). The hazard model for European SMEs: Combining accounting and macroeconomic variables. *Journal of Competitiveness*, 14(3), 76–92. <https://doi.org/10.7441/joc.2022.03.05>
- Karas, M., & Reznakova, M. (2020). Cash Flows Indicators in the Prediction of Financial Distress. *Engineering Economics*, 31(5), 525–535. <https://doi.org/10.5755/j01.ee.31.5.25202>
- Karas, M., & Reznakova, M. (2021). The role of financial constraint factors in predicting SME default. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 16(4), 859–883. <https://doi.org/10.24136/eq.2021.032>
- Karas, M., & Reznakova, M. (2023). A novel approach to estimating the debt capacity of European SMEs. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 18(2), 551–581. <https://doi.org/10.24136/eq.2023.017>
- Kliestik, T., Valaskova, K., Kliestikova, J., Kovacova, M., & Svabova, L., (2019). *Prediction of financial health of business entities in transition economies*. Zilina: EDIS.
- Kliestik, T., Valaskova, K., Lazaroiu, G., Kovacova, M., & Vrbka, J. (2020). Remaining financially healthy and competitive: The role of financial predictors. *Journal of Competitiveness*, 12(1), 74–92. <https://doi.org/10.7441/joc.2020.01.05>
- Kovacova, M., & Kliestik, T. (2017). Logit and Probit application for the prediction of bankruptcy in Slovak companies. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 12(4), 775–791. <https://doi.org/10.24136/eq.v12i4.40>
- Kovacova, M., Kliestik, T., Valaskova, K., Durana, P., & Juhaszova, Z. (2019a). Systematic review of variables applied in bankruptcy prediction models of Visegrad Group countries. *Oeconomia Copernicana*, 10(4), 743–772. <https://doi.org/10.24136/oc.2019.034>
- Kovacova, M., Valaskova, K., Durana P. & Kliestikova, J. (2019b). Innovation management of the bankruptcy: Case study of Visegrad Group countries. *Marketing and Management of Innovations*, 4, 241–251. <http://doi.org/10.21272/mmi.2019.4-19>
- Maros, M. (2024). *Ekonomicka statistika*. Nitra: Univerzita Konstantina Filozofa v Nitre.
- Niessner, T., Gross, D. H., & Schumann, M. (2022). Evidential strategies in financial statement analysis: A corpus linguistic text mining approach to bankruptcy prediction. *Journal of Risk and Financial Management*, 15(10), 459. <https://doi.org/10.3390/jrfm15100459>
- SARIO. (2025). *Mechanical engineering industry in Slovakia*. SARIO. <https://www.sario.sk/sites/default/files/sario-mechanical-engineering-industry-in-slovakia2025-02-28.pdf>
- SK NACE. (2024). SK NACE podľa ICO. SK NACE. <https://www.sk-nace.sk/sk-nace-podla-ico/>
- Slosarova, A., & Blahusiakova, M. (2017). *Analýza uctovnej zvierky* (1st ed.). Bratislava: Wolters Kluwer SR.
- Teplicka, K. (2016). *Ekonomicka statistika* (1st ed). Kosice: TU FBERG.
- Titko, M., Novak, L., & Janosikova, M. (2021). *Prakticka statistika*. Zilina: EDIS.
- Uradnicek, V., Kral, P., Bielikova, T., Cut, S., Stachova, M., & Kollar, I. (2016). *Variacne metody predikcie financneho zdravia podnikov v podmienkach dynamickeho prostredia* (1st ed). Banska Bystrica: Belianum.
- Valaskova, K., & Podhorska, I. (2017). Prediction models in the context of international environment. In *Globalization and its socio-economic consequences* (pp. 2792–2800). University of Zilina.
- Valaskova, K., Gajdosikova, D., & Belas, J. (2023). Bankruptcy prediction in the postpandemic period: A case study of Visegrad Group countries. *Oeconomia Copernicana*, 14(1), 253–293. <https://doi.org/10.24136/oc.2023.007>
- Valaskova, K., Gavurova, B., Durana, P., & Kovacova, M. (2020). Alter ego only four times? The case study of business profits in the Visegrad Group. *E&M Economics and Management*, 23(3), 101–119. <https://doi.org/10.15240/tul/001/2020-3-007>

- Valaskova, K., Kliestik, T., & Kovacova, M. (2018). Management of financial risks in Slovak enterprises using regression analysis. *Oeconomia Copernicana*, 9(1), 105-121. <https://doi.org/10.24136/oc.2018.006>
- Zalai, K., David, A., Snircova, J., Moravcikova, E., Hurtosova, J., & Tucnikova, D. (2016). *Financno-ekonomicka analyza podniku* (9th revised and expanded ed.). Bratislava: Sprint 2.