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THE IMPACT OF MACROECONOMIC FACTORS ON THE PROFITABILITY OF COMPANIES. ANALYSIS USING NEURAL NETWORKS

Dawid SZUTOWSKI

Poznań University of Economics and Business; dawid.szutowski@ue.poznan.pl, ORCID: 0000-0002-5841-4973

Purpose: Despite the central role of profitability in economic analysis, previous research has yielded diverse and often unstructured conclusions regarding its determinants. To address this gap, this empirical investigation aimed to explore the major determinants of company profitability.
Design/methodology/approach: It conducted a comprehensive analysis of factors, encompassing: changes in the gross domestic product, Consumer Price Index, Producer Price Index, NBP's Reference rate, investment outlays, intramural expenditures on research and development, expenditures on innovation activities in enterprises, and patents granted, alongside company-level profitability indicators. The study's sample consisted of companies representing 19 sectors of the economy, spanning from 2004 to 2021. For data analysis, a neural network was employed, specifically a multi-layer perceptron (MLP) utilizing the sigmoid activation function.
Findings: The findings suggest that alterations in macroeconomic variables can significantly impact the profitability of companies. The analysis carried out revealed that consumer price index, reference rate, gross domestic product and producer price index were the most important exogeneous factors.
Originality/value: This study introduces several novelties, including the application of neural networks, which are infrequently utilized in this field, and the simultaneous analysis of a comprehensive set of independent variables.
Keywords: profitability, macroeconomic indicators, neural network.
Category of the paper: Research paper.

1. Introduction

Despite the central role of profitability in economic analysis, previous research has yielded diverse and often unstructured conclusions regarding its determinants. While it has been abundant in studying endogenous factors, it was also notably less focused on exogenous ones. To address this imbalance, this study primarily examines the sectoral and macroeconomic determinants of profitability.

The review of existing literature underscores the significance of the external environment in shaping company profitability. Surprisingly, both researchers and practitioners frequently neglect exogenous factors, detaching their analyses from the broader business environment. The importance of external factors in profitability analysis is particularly apparent in practical contexts, such as valuation, transactional analysis, financial analysis, operational and strategic analysis, and bankruptcy prediction. However, the general understanding of the role of exogenous factors in profitability analysis has limitations. The spectrum of sectoral and macroeconomic variables studied to date lacks consistency, prior studies often produce conflicting results due to limited empirical evidence, and traditional research methods have been routinely employed.

In light of these considerations, this paper aims to explore the major determinants of company profitability. It hypothesizes that all selected variables significantly affect company profitability.

The empirical study employed a dataset of companies representing the 19 sectors of the economy, spanning from 2004 to 2021. The initial number of data points matched 108.300 (300 companies * 19 sections * 19 years), but for the computational procedure, the data was aggregated on the sectoral level. To operationalize variables, twelve factors — changes in the gross domestic product, the Consumer Price Index, the Producer Price Index, NBP's Reference rate, investment outlays in periods t and t-1, intramural expenditures on research and development in periods t and t-1, expenditures on innovation activities in enterprises in periods t and t-1, and patents granted in periods t and t-1 — were considered. Four distinct measures of company profitability — ROE, ROA, ROS, and ROIC — were used. Data analysis was conducted using a neural network, specifically a multi-layer perceptron (MLP), comprising an input layer, an output layer, and a hidden layer with no restrictions on neuron count. Variables were appropriately rescaled, and a sensitivity analysis assessed variable importance.

The results indicate that changes in macroeconomic variables may significantly influence company profitability. Notably, the most influential macroeconomic variables were Consumer Price Index, Reference rate, changes in gross domestic product and Producer Price Index. Other variables demonstrated relatively lower importance.

The structure of this paper comprises a literature review highlighting profitability's role in economic analysis and presenting existing evidence on determinants of profitability. It is followed by an exposition of the research methods, with specific focus on the neural network employed for data analysis. The results are subsequently presented and discussed in comparison to previous findings in the field, concluding with overarching insights.

2. Literature review

Profitability remains a central element in economic analysis because of its crucial role in operations and its significance as a key factor influencing a company's value (Dang, Vu, Ngo, Hoang, 2019). However, it's worth noting that profitability is influenced by various factors, and the existing scientific evidence on this topic is somewhat fragmented. To address this gap, this research proposes a comprehensive approach that involves analysing a wide array of variables.

Given that profitability acts as a vital link connecting a company's operational environment to its overall value, it holds a central position in financial management and necessitates a thorough understanding. At its core, profitability measures the return a company generates within a specific period relative to the underlying causal factor. Profitability ratios typically combine financial results with metrics such as sales, assets, the value of equity, or the total capital invested in the company. As a result, profitability analysis enables the assessment of a company's performance across various dimensions, each with its unique characteristics.

Both from financial and managerial perspectives, profitability is evaluated throughout day-to-day operations and in the formulation of strategic plans. Well-managed enterprises generally aim to enhance their profitability. The importance of profitability is further underscored by analytical practice, as demonstrated by the assertion that " the ability to generate profit on capital invested is a key determinant of a company’s overall value and the value of the securities it issues. Consequently, many equity analysts would consider profitability to be a key focus of their analytical efforts" (Robinson, Greuning, Henry, Broihahn, 2020, p. 291).

Profitability is influenced by a broad spectrum of factors, including both internal and external ones. While there is a wealth of research on the internal determinants of profitability, the body of evidence concerning the relationship between company profitability and macroeconomic variables is less extensive and will be the central focus of this study. This gap is particularly significant in open economies where there is a high degree of interdependence among companies, sectors, and nations. Current evidence suggests that in the global economy, companies are particularly vulnerable to various threats stemming from the unstable and uncertain business environment, both at the individual country level and within the global economy (Batra, Kalia, 2016).

In the context of studies examining the relationship between macroeconomic variables and company profitability, a review of the literature reveals some of the most commonly employed external (macroeconomic) variables. Although the research in this area remains somewhat fragmented, there are certain similarities that can be observed across various studies. For instance, in a study conducted in Greece, which examined non-financial Greek firms listed on the Athens Exchange, the findings indicated that company profitability is positively affected by factors such as company size, sales growth, and investment, while it is negatively impacted

by leverage and current assets. From an external perspective, the research suggested a negative relationship between a firm's participation in the European monetary union and the adoption of the euro and its profitability (Asimakopoulos, Samitas, Papadogonas, 2009). Subsequent research further delved into the division of internal and external factors affecting profitability, analysing both aspects. Notably, one of the key findings emphasized a significant and negative correlation between the return on assets and changes in gross domestic product (GDP) and the inflation rate (Khrawish, 2011). These findings were partially supported by later studies, which revealed that, in the case of banks, higher rates of economic growth had a negative impact on profitability, while higher inflation rates had a positive influence (Sufian, 2009; Sufian, Noor, 2012). Continuing in this vein, subsequent research reaffirmed the importance of external (macroeconomic) variables in shaping a company's profitability. This research examined a sample of 108 banks specializing in real estate financing, located in the USA, Great Britain, and Germany. The results demonstrated that variables such as the Lerner Index, interest rate volatility, and the level of GDP significantly affected company profitability (Martins, Serra, Stevenson, 2019).

Furthermore, previous evidence suggests that the relationship between reference rates and the profitability of companies is significant. The principal argument provided here is that the reference rates influence the borrowing costs (Santsuosso, 2014). Furthermore, when it comes to working capital, again – changes in reference rates can affect the interest rates on the short-term loans and credit lines, impacting the cost of financing day-to-day operations. Thus, higher reference rates can increase expenses on the short-term borrowings, potentially squeezing profitability (Muscettola, Naccarato, 2016). Furthermore, for the companies involved in international trade, reference rates are of vital importance, as the changes may influence the exchange rate of the national currency (Basatry, Shella, 2019).

Next, using the example of renewable energy sector, it was suggested that the profitability of companies is primarily contingent on the stability and predictability of policies that promote renewable energy development in specific countries (Chebotareva, 2018). What stands out as particularly significant in this context is the inclusion of an investment perspective in this study. This holds crucial importance both from a scientific and practical standpoint, given that in some sectors the technological advancement may necessitate substantial investments.

Moreover, a substantial body of knowledge concerns the relation between R&D, patent and innovation-related activities and company profitability. In line with previous studies innovation, whether manifested through product development, process optimization, or strategic differentiation, holds the potential to significantly enhance a firm's profitability (Love, Roper, Du, 2009). On the revenue side - novel and improved products often command premium prices, contributing directly to revenue augmentation. Furthermore, innovation-driven operational efficiencies can curtail marginal costs (Jaumandreu, Mairesse, 2015), consequently augmenting profit margins. In the similar vein, previous evidence suggests that R&D investments serve as a critical driver of long-term profitability. While R&D expenses may

initially burden a firm's financial statements, they often yield substantial returns through enhanced product offerings, improved efficiency, and competitive advantage. In line with previous evidence the relationship between R&D spending and firm performance resembles an inversed U-shape (Guo, Wang, Wei, 2018). In reference to patents, it was observed that they can substantially influence a company's profitability. More specifically, based on the analysis of patent portfolios it was suggested that the broad patent diversity is effective when the focal firm has very high technology stocks and profitability is used as a performance measure. The core field diversity is effective for a focal firm with above average technology stocks and where shareholder value is considered as a performance indicator (Ling, Chen, Wu, 2006). Patents also create opportunities for licensing or selling intellectual property rights, generating additional revenue streams (Lin, 2011).

Therefore, the analysis of the previous evidence points to changes in gross domestic product, inflation, reference rates, investment, R&D and innovation as the most commonly employed factors shaping company profitability.

3. Research methods

The study's design was grounded in the theoretical framework outlined in the previous section, facilitating an examination of the connection between key factors and company profitability. Consequently, the empirical investigation required a customized approach. To begin, it integrated two perspectives: internal and external. This approach involved the use of a broad range of variables, spanning from macroeconomic indicators to specific company-level profitability metrics. Second, given the relatively limited variation in macroeconomic and sectoral metrics, a sufficiently extended time span was necessary. In this study, the analysis encompassed the years 2004 to 2021. Third, recognizing that external and internal dynamics diverge and that the transmission of changes in sectoral and macroeconomic conditions to businesses depends on intersectoral business connections and can take a significant amount of time (Nguyen, Chevapatrakul, Mateut 2022), the issue of time lag needed to be addressed. Consequently, lagged variables were included in the model. Fourth, as this study analytically adopts a sectoral-perspective all the variables were aggregated or measured at the sector or country-wide levels.

The research targeted all the sectors characterised by Statistics Poland except for sections T (households with employees; households producing products and providing services for their own needs) and U (extraterritorial organizations and teams) and therefore, it covered 19 sectors. In each sector 300 companies were randomly drawn. This sample size was determined based on the statistical principles, where adapting z-alpha of 1.65 and the estimation error of 5% results in the sample size matching 272 observations. Next, this number was rounded up.

As in the study yearly data was gathered, the initial (before aggregation) number of data points matched 108.300 (300 companies * 19 sections * 19 years). However, the final number was smaller because of the cases with user-missing values on factors and dependant variables and the elimination of outliers. The remaining cases were then averaged in order to produce the sectoral average measures of profitability. All the subsequent calculations were performed based on the sectoral averages, which resulted in 361 data points (19 sectoral averages * 19 years).

To effectively combine internal and external perspectives, it was essential to establish a well-structured operational approach. This operationalization necessitated the careful selection of key variables, a process guided by a review of relevant literature. In the realm of macroeconomic factors, twelve variables were chosen: changes in the gross domestic product (referred to as changes in GDP), the Consumer Price Index (referred to as CPI), the Producer Price Index (referred to as PPI)[1], NBP's Reference rate (referred to as Reference rate), investment outlays in periods t and t-1 (referred to as Investment (t) and Investment (t-1)), intramural expenditures on research and development in periods t and t-1 (referred to as R&D (t) and R&D (t-1)), expenditures on innovation activities in enterprises in periods t and t-1 (referred to as Innovation (t) and Innovation (t-1)), patents granted in periods t and t-1 (referred to as Patents (t) and Patents (t-1)). These variables aligned with those commonly employed in most of the studies under examination, including those specifically conducted in Poland. As previously stated, Investment (t and t-1), R&D (t and t-1) Innovation (t and t-1) and Patents (t and t-1) were all aggregated, economy-wide measures.

As for assessing company profitability, given its multifaceted nature, using a single measure as a proxy would have been inadequate. Hence, four distinct profitability measures were employed: Return on Equity (ROE), Return on Assets (ROA), Return on Sales (ROS), and Return on Invested Capital (ROIC). It's worth noting that there is no universally accepted, standard set of formulas for computing these indicators, and formulaic variations often exist depending on the specific researcher or data source. Therefore, precise calculation methods had to be established. In this article, the approach that appears to be one of the most methodologically robust was adopted, wherein:

$$ROE = \frac{\text{net profit}}{\text{average total equity}} \tag{1}$$

$$ROA = \frac{\text{net profit}}{\text{average total assets}} \tag{2}$$

$$ROS = \frac{\text{net profit}}{\text{revenues}^{\,2}} \tag{3}$$

$$ROIC = \frac{\text{EBIT} * (1-\text{t})}{\text{total equity} + \text{interest bearing debt}} \tag{4}$$

[1] More accurately, Statistics Poland calculates the Price indices of sold production of industry, which cover four industries: "Mining and quarrying", "Industrial processing", "Electricity, gas, steam and hot water production and supply" and "Water supply, sewage and waste management, reclamation" (Statistics Poland, 2023B).

[2] Revenues were calculated as the sum of net sales revenues, other operating income and finance income.

These equations have been extensively examined in the literature (Mikołajewicz, Nowicki, 2021) and are endorsed by specialized organizations such as the CFA Institute (Robinson, Greuning, Henry, Broihahn, 2020).

For the data analysis process, a neural network, specifically a multi-layer perceptron (MLP), was employed. While this approach was infrequently utilized in this context, it underwent preliminary testing (Szutowski, 2023). Initial tests indicated that the MLP network outperformed the radial basis function. Concerning the network's structure, the input layer comprised 12 variables representing all the selected factors, in some cases examined in both the current (t) and previous (t-1) periods. This corresponds to the need of analysing the delayed effects of changes in some external factors. The included variables were: GDP, CPI, PPI, Investment (t), Investment (t-1), R&D (t), R&D (t-1), Innovation (t), Innovation (t-1), Reference rate, Patents (t) and Patents (t-1). The output layer consisted of the four target profitability variables for the current period (t), namely ROE, ROA, ROS, and ROIC. There were no restrictions on the number of neurons in the hidden layer. As per theoretical considerations, all variables underwent appropriate rescaling (IBM, 2023). Covariates were rescaled using adjusted normalization, while scale dependents were standardized. Normalization was chosen as it is recommended for the sigmoid activation function used in this study. The division of data into training, testing and holdout sets was performed automatically using the proportions of 50%, 25% and 25% consecutively. An overview of case processing, including the division into training and testing samples, is presented in Table 1.

Table 1.
Case processing summary

		N	Percent
Sample	Training	174	48.2%
	Testing	92	25.5%
	Holdout	95	26.3%
Valid		361	100.0%
Excluded		0	
Total		361	

Source: own development.

The chosen learning approach was batch learning, where weight updates are based on information derived from the entire dataset. This type of learning is recommended because it minimizes the overall error and is particularly suitable for relatively small to medium-sized datasets, such as the one being studied here.

Since neural networks don't offer regression-like coefficients for independent variables, a separate analysis was conducted to assess the importance of these variables. To achieve this, a sensitivity analysis was performed, which determines the significance of each predictor in shaping the neural network (IBM, 2019). Given that the number of predictors was not excessively large, the sensitivity analysis did not pose significant computational or time-related challenges. IBM SPSS software was used for constructing the neural network.

This study drew data from two primary sources. First, macroeconomic data were sourced from the Macroeconomic Data Bank, a service provided by Statistics Poland. According to the source's description, it is a statistical database that compiles indicators characterizing the macroeconomic and social conditions in Poland. This database offers access to extensive time series data covering various macroeconomic categories (Statistics Poland, 2023A). Second, the endogenous financial data used for calculating profitability ratios were gathered from the EMIS (Emerging Markets Information Service) database. As per the database provider, EMIS offers access to financial information for 682 thousand companies registered in Poland, including both large and smaller businesses (EMIS, 2022).

Regarding the study's objective, which was to explore the major determinants of company profitability, this research indicates that alterations in macroeconomic variables could significantly impact the profitability of companies.

A detailed overview of the network structure, encompassing the input, hidden, and output layers is provided below. This summary provides essential insights into the network's configuration, covering the variables employed, the methods of rescaling, as well as the activation and error functions. To enhance clarity, this information is conveniently presented in a tabular format (see Table 2).

Table 2.
Network information

Input Layer	Covariates	1	GDP
		2	CPI
		3	PPI
		4	Investment (t)
		5	R&D (t)
		6	Innovation (t)
		7	Reference rate
		8	Investment (t-1)
		9	R&D (t-1)
		10	Innovation (t-1)
		11	Patents (t)
		12	Patents (t-1)
	Number of Units[a]		12
	Rescaling Method for Covariates		Normalized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1a		8
	Activation Function		Sigmoid
Output Layer	Dependent Variables	1	ROS
		2	ROA
		3	ROE
		4	ROIC
	Number of Units		4
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
	Error Function		Sum of Squares

a – excluding the bias unit.

Source: own development.

Next, an overview of the model is provided. The results obtained for the training, testing and holdout datasets align closely to one another. The criterion for concluding the network's learning process was based on observing a single consecutive step with no decrease in error. Consequently, the relative errors for the training set equalled 0.499, for the testing set it was 0.717 and for the holdout set it matched 0.561. For specific details, refer to Table 3 below, which shows that in the testing set, ROA exhibited the highest relative error, while ROE had the lowest. Comprehensive details of the estimated parameters can be found in the Appendix.

Table 3.
Model summary

Training	Average Overall Relative Error		.499
	Relative Error for Scale Dependents	ROS	.517
		ROA	.524
		ROE	.452
		ROIC	.502
	Stopping Rule Used		1 consecutive step(s) with no decrease in error[a]
	Training Time		0:00:00.16
Testing	Average Overall Relative Error		.717
	Relative Error for Scale Dependents	ROS	.512
		ROA	.773
		ROE	.511
		ROIC	.742
Holdout	Average Overall Relative Error		.561
	Relative Error for Scale Dependents	ROS	.537
		ROA	.734
		ROE	.528
		ROIC	.581

a – error computations are based on the testing sample.

Source: own development.

To evaluate the model's performance, both the mean absolute error (MAE) and the mean squared error (MSE) were employed. To prevent any potential bias, the conventional MSE formula was adjusted, incorporating a denominator in the form of N - 1 - p, where 'p' represents the count of input variables (Karłowska-Pik, 2022). It's worth noting that for each of the dependent variables, the smallest errors were observed for ROA. The specific outcomes for each of these dependent variables are presented in Table 4.

Table 4.
Mean absolute error and mean squared error

	ROS	**ROA**	**ROE**	**ROIC**
MAE	0.31	0.06	0.11	0.66
MSE	1.08	0.13	0.26	0.79

Source: own development.

The next section of the paper presents and discusses the specific results.

4. Results

The comprehensive outcome of the analysis is depicted in Figure 1. As previously mentioned, the network was composed of not only the input and output layers but also featured a solitary hidden layer with eight neurons. Additionally, both the input and hidden layers incorporated a bias unit. In the diagram provided below, the network structure is presented, with grey lines representing synaptic weights greater than zero, and blue lines signifying synaptic weights less than zero.

Because the results obtained do not directly reveal the connection between the input layer variables and the output layer variables, a sensitivity analysis was conducted. This analysis served to identify the significance of each individual variable within the input layer. The outcomes are detailed in Table 5 and will be discussed further below.

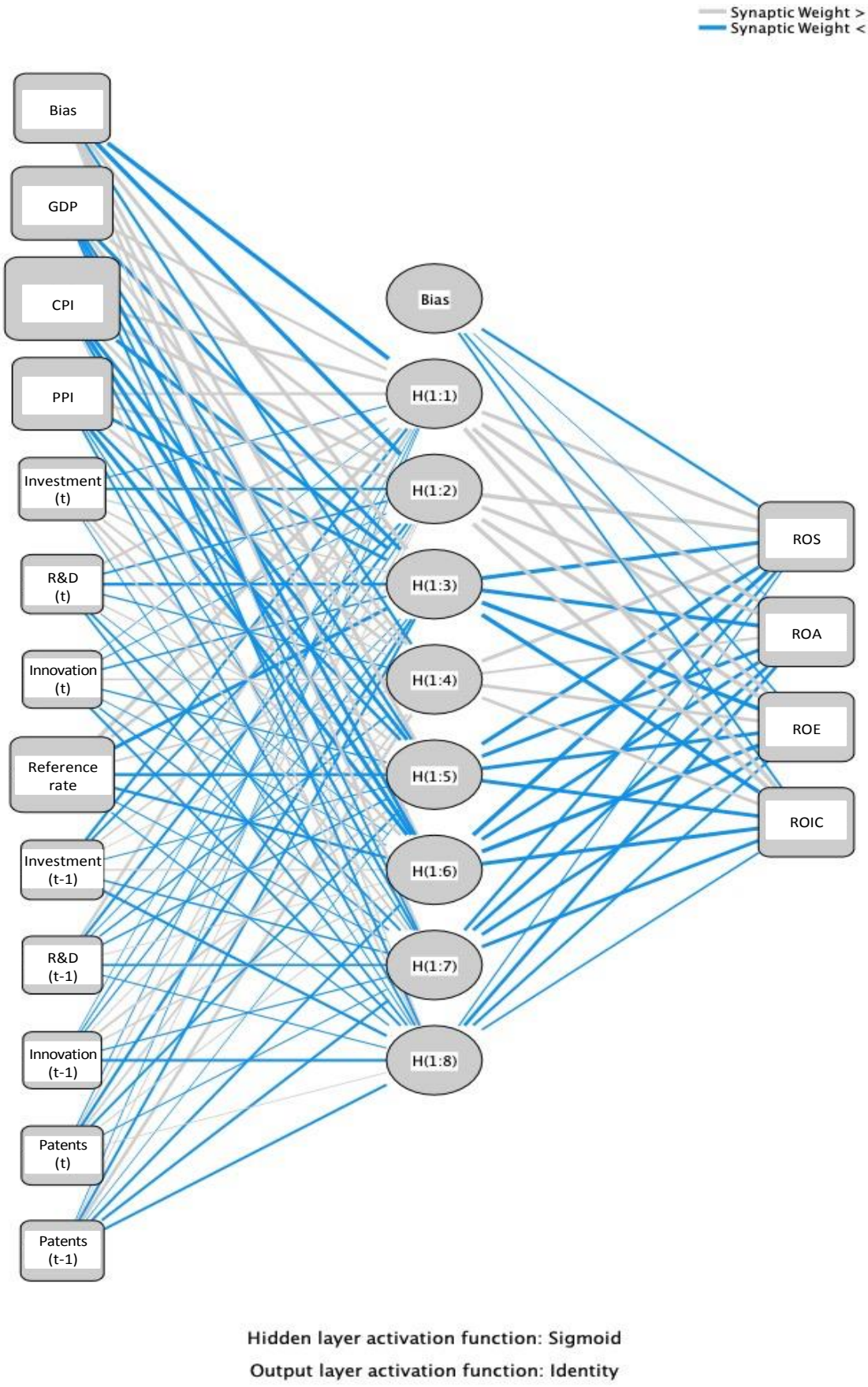

Figure 1. Synaptic weights.

Source: own development.

Table 5.
Independent variable importance

Variable	Importance	Normalized Importance
GDP	.159	64.5%
CPI	.247	100.0%
PPI	.151	61.2%
Investment (t)	.065	26.5%
R&D (t)	.033	13.2%
Innovation (t)	.018	7.5%
Reference rate	.177	71.9%
Investment (t-1)	.037	14.9%
R&D (t-1)	.022	8.8%
Innovation (t-1)	.014	5.5%
Patents (t)	.033	13.4%
Patents (t-1)	.044	17.8%

Source: own development.

To facilitate a more accessible understanding of the results pertaining to the importance of these sector-specific and macroeconomic variables, they will be visually represented in Figure 2.

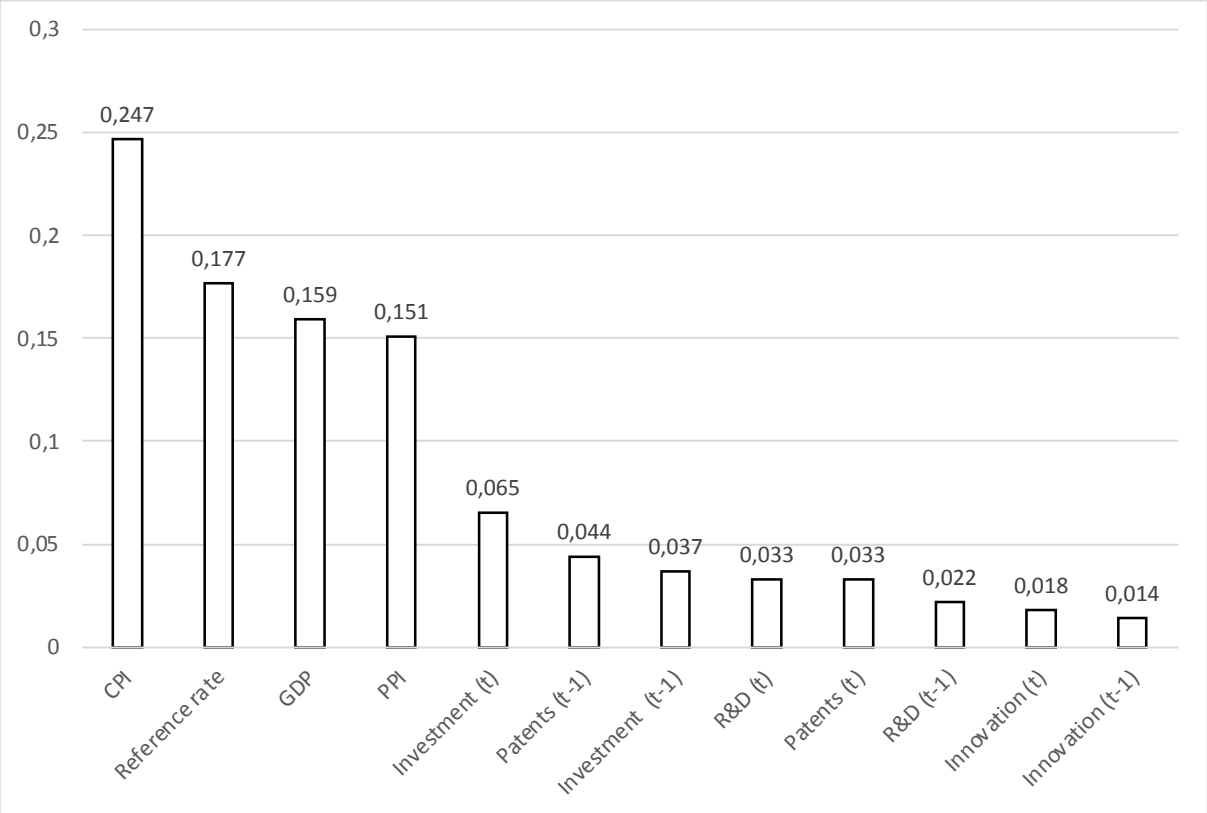

Figure 2. Importance of exogeneous variables.

Source: own development.

The analysis carried out revealed that, concerning the profitability of companies, the Consumer Price Index is the most significant macroeconomic variable. This outcome aligns with earlier research, which has consistently indicated a robust correlation between inflation and company profitability (Khrawish, 2011; Sufian, 2009; Sufian, Noor, 2012). It might be

hypothesised here that demand-pull inflation might enhance profitability, while cost-push inflation may have the opposite effect, as discussed in Sangkyun's study in 2022.

The second most important factor was Reference rate. It is consistent with previous evidence suggesting significant impact of reference rates on the profitability of companies. One might hypothesise that the effect observed here derives from the fact that the reference rates influence the borrowing costs (Santsuosso, 2014). Also, as the reference rate undergone significant changes in the period of analysis, the credit availability differed from one period to another determining company ability to finance expansion, invest in new projects, or meet working capital needs, all of which affect company profitability (Muscettola, Naccarato, 2016). Moreover, as the sample studied here encompasses the companies of all the sectors of the economy, it also includes companies involved in international trade. Thus, the significance observed here may be partially explained by the fact that the fluctuations of the reference rate influenced the exchange rate of the PLN affecting the profitability of those companies.

Furthermore, alterations in the gross domestic product (GDP) ranked as the third most influential macroeconomic factor. This variable provides a broad indication of the overall economy's size and performance, making its connection to company profitability relatively straightforward. In accordance with previous empirical findings, consumer spending is closely linked to economic performance, and increased consumption (e.g. electricity) is correlated with higher GDP levels (Diacon, Maha, 2015; Stern, Burke, Burns, 2017). Adhering to fundamental economic principles, all else being equal, increased production levels result in changes primarily in variable costs. This effect, in the presence of fixed costs, enables companies to enhance their profitability.

The importance of the Producer Price Index (PPI) on moulding a company's profitability appears to be well-founded from a substantive perspective. It seems reasonable to hypothesise that the explanation provided for CPI holds true also here. Both the demand-pull inflation and the cost-push inflation may exert a significant effect on company profitability (Sangkyun, 2022). As the PPI variable signifies fluctuations in the fundamental prices within the industrial sector, which includes electricity, gas, steam, and hot water production and supply, changes in PPI transmit directly or indirectly into all of the sectors under investigation.

It appears that the above variables account for 0,734 of the total importance (0,159 + 0,247 + 0,151 + 0,177 = 0,734), which makes the remaining variables meaningfully less important. Investment (both t and t-1) and Patents (t-1) exerted some minor effect on profitability. However, when it comes to investment, previous research suggested already that there is no strong negative (or positive) impact of investment intensity on the future rates of ROA (Kotsina, Hazak, 2012). From the point of view of time lags, it might be worth noting that all the above-discussed variables conveyed the values in given period (t), while Patents (t-1) and Investment (t-1) were the most important lagged (t-1) variables in the set. This result seems partially consistent with earlier evidence concerning investment time lags. Previous studies suggested that when it comes to the length of investment projects, depending on the sector,

it might be significant (Bar-Ilan, Strange 1996). It is therefore reasonable that the effects of investment outlays are only apparent after some time. In the case of patents, previous evidence also suggested that in some sectors their effects are only visible after some time (Ken, Tsai, Ou, 2008).

The remaining variables, i.e. R&D, Patents, R&D (t-1), Innovation and Innovation (t-1) demonstrated a relatively low importance. Therefore, the results of the study partially contradict the initially hypothesised importance of all the selected variables in shaping company profitability.

5. Conclusions

Due to the pivotal role of profitability in economic analysis and the varying empirical evidence on the influence of external factors on it, this study aimed to explore the major determinants of company profitability. While the study hypothesized the important impact of all selected variables on shaping company profitability, the findings offered partial support. Results indicated that changes in macroeconomic variables could exert a notable effect on the profitability of companies. Among the macroeconomic factors, the CPI emerged as the most influential, followed by Reference rate, GDP and PPI. The remaining factors exhibited relatively lower importance, particularly the Innovation (t) and Innovation (t-1).

These results hold practical relevance, as they emphasize the importance of incorporating external factors into profitability analysis, which is essential for various analytical works and expert opinions. This study underscores the need to consider the environment in which a company operates to draw reliable conclusions.

Notwithstanding this conclusion, the study identified promising avenues for further research. Firstly, some of the extensively studied factors related to innovation, R&D and patents demonstrate low importance, which contradicts most previous evidence in the field. Because of that, further investigation seems an important direction of future research. Second, this research did not address the inter-sectoral differences. While it was not its purpose, the following studies could focus on the characteristics of particular sectors and differentiate the results with consideration respect to them.

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Appendix

Table 6.
Parameter estimates

Predictor		Predicted											
		Hidden Layer 1								Output Layer			
		H(1:1)	H(1:2)	H(1:3)	H(1:4)	H(1:5)	H(1:6)	H(1:7)	H(1:8)	ROS	ROA	ROE	ROIC
Input Layer	(Bias)	-2.577	-2.399	1.921	-.652	1.679	.948	.800	.178				
	GDP	.806	1.248	-1.392	.996	-.764	-1.070	-.400	-.452				
	CPI	1.370	1.875	-1.873	.807	-1.403	-2.162	-.572	.353				
	PPI	.838	.929	-1.023	1.032	-.873	-1.417	-.185	-.416				
	Investment (t)	-.184	-.628	.245	.314	.471	.787	.414	-.105				
	R&D (t)	.737	-.383	-.946	-.250	.235	-.043	-.431	-.369				
	Innovation (t)	-.014	-.096	-.304	.251	-.236	-.060	-.267	-.457				
	Reference rate	1.969	1.001	-1.525	.359	-.942	-.787	-.158	-.222				
	Investment (t-1)	-.630	-.423	.285	.030	-.130	.235	-.302	-.700				
	R&D (t-1)	.770	-.546	-.092	-.272	-.269	.091	-.456	-.173				
	Innovation (t-1)	-.010	-.173	-.193	.110	.469	.267	-.198	-.696				
	Patents	-.093	.233	-.689	.366	-.438	.128	-.149	.050				
	Patents (t-1)	-.055	.087	-.528	.912	-.018	-.544	-.611	-.603				
Hidden Layer 1	(Bias)									-.740	-.029	-.344	-.419
	H(1:1)									2.143	3.042	2.323	2.587
	H(1:2)									3.171	2.251	3.042	2.981
	H(1:3)									-2.304	-2.284	-2.615	-2.503
	H(1:4)									1.685	.545	1.113	.969
	H(1:5)									-1.786	-1.596	-1.589	-1.763
	H(1:6)									-2.345	-1.302	-2.354	-2.003
	H(1:7)									-.801	-1.063	-1.055	-1.134
	H(1:8)									-.207	-1.015	-.637	-.348