The Impact of Sustainable Development on Financial Performance with The Role of Artificial Neural Networks as A Moderate Variable in Iraq

Abbas Jumaah Al-Waeli[1]

[1] Department of Accounting, Mazaya University College, Iraq

Correspondence: Abbas Jumaah Al-Waeli, Department of Accounting, Mazaya University College, Iraq. ORCID ID: https://orcid.org/0000-0002-4166-1222. E-mail: ac.abbas.al-waeli@mpu.edu.iq

Received: April 9, 2026 Accepted: May 1, 2026 Online Published: May 13, 2026

doi:10.5430/afr.v15n2p36 URL: https://doi.org/10.5430/afr.v15n2p36

Abstract

In this paper, we analyzed the relationship between sustainable development practices and the financial performance of Iraqi industrial companies and investigated the moderating effect of artificial neural networks. Given the significance of sustainability as a worldwide issue, this study seeks to fill the research gap regarding sustainability in developing economies. Different metrics for sustainability and financial performance are evaluated through analysis of empirical data of Iraqi industrial organizations. This study uses artificial neural networks to assess their contribution to improving these interactions. It finds that sustainability activities lead to better financial performance, so the focus on environmental, social and governance (ESG) issues does indeed matter. Moreover, artificial neural networks significantly improve the accuracy of the prediction of financial performance using sustainability criteria. Corporations that employ sustainable practices and advanced computational techniques also obtain superior financial results through those applications. This publication contributes to the theoretical discourse on sustainability, financial performance, and artificial intelligence by developing action-oriented suggestions for industry leaders in Iraq. It also directs the next phase of research and policy development for sustainable industrial advancement.

Keywords: sustainable development, financial performance, artificial neural networks, Iraqi industrial enterprises, computational methodologies, sustainability indicators

1. Introduction

At a moment when sustainability is a focal point of the world agenda, understanding the connections between sustainable development and financial performance is of paramount importance to researchers and practitioners. Sustainable development, which is the ability to meet current demands without compromising the capability of future generations to meet their needs, is considered by many as critical to enduring economic stability and environmental well-being (Brundtland Commission, 1987). We thus examine the effect of sustainable development programs on financial performance of Iraqi industrial companies and identify gaps in the literature of developing countries such as Iraq. Notwithstanding a large body of work on similar problems in some other contexts, the industrial dynamics in Iraq generate specific challenges and opportunities that warrant in-depth examination (Al-Zubaidi, 2021; Al-Saadi & Al-Ali, 2020). Sectors such as manufacturing are important in Iraq's economic development yet, they have limitations such as political instability, inadequate infrastructure, as well as environmental degradation. Adopting sustainable development approaches to overcome these challenges in this sector can positively impact sectorial financial performance. To prove this concept using a range of sustainability and financial performance criteria, this study seeks to confirm it and empirically evaluate it (Jasim & Hussein, 2019; Al-Waeli et al., 2022).

It focuses on sustainable development with the addition of modern computational tools, namely artificial neural networks (ANNs), to perform the analysis of complex relationships. Neural networks like ANNs, whose very nature reflects the brain, understand the behaviour and process vast amounts of data and recognize patterns that statistical analysis could fail to capture. The aim of this research is to unravel the moderating influence of artificial neural networks (ANNs) on the relationship between sustainable development and financial performance (Khan & Shah, 2020).

Hence, this research is meaningful for its application for theoretical and practical purposes. It presents a new approach to sustainability, which theoretically adds to our current understanding of how sustainability and financial performance are defined by recent computational approaches. In addition, by providing practical insights on solutions that empower the corporate citizen in Iraq to achieve financial success while fostering corporate sustainability, it supports policymakers and business leaders. The outcomes could be regarded as a model for other developing economies experiencing similar problems and looking for sustainable economic development (Al-Khafaji, 2022). This work is organised as follows: Following the introduction, an in-depth literature review of relevant theories and previous research is conducted. This is followed by a comprehensive chapter which describes the research methodology. Empirical findings are detailed in the results section and followed by interpretation and debate. Finally, recommendations and areas for future research are extended to this area of study.

2. Literature Reviews

Sustainable development methods are increasingly becoming important and are supported by multiple studies which suggest their positive impacts on multiple organizational outcomes. There is significant evidence linking sustainability activities with enhanced financial performance, often explained in terms of efficiency, reputation, and long-term viability (Eccles et al., 2014). Dyllick and Hockerts (2002) have defined three main elements of sustainable development, known collectively as the triple bottom line: economic, social, and environmental.

This theory holds that organizations which take these qualities into action gain a sustainable balance in order to achieve comprehensive success. With special challenges, the industrial sector in Iraq faces a variety of socio-political difficulties and infrastructure deficiencies which pose a threat to sustainable development practises. Nonetheless, Iraqi manufacturing companies are catching much of the possibilities of the above-mentioned measures (Hassan & Khalid, 2022). Using artificial neural networks to predict financial performance has been proved to be promising since several studies appeared. For example, in a joint study by Trippi and Turban (1993), they showed how much stronger prediction skills artificial neural networks have when compared with traditional statistical methods in stock market analysis. The advantages of ANN make it an influential tool in illuminating the multi-dimensional effects of sustainable development policies on financial performance. The literature provides extensive evidence that sustainable ways of development improve financial performance. In addition, the integration of advanced computational approaches, for example artificial neural networks, assists in elucidating these complex connections and thus provides theoretical and practical progress. The study attempts to bring such principles to bear on Iraq to inform the more general debate of sustainability, financial performance and innovation.

2.1 Iraqi Industrial Companies

Due to the creation of jobs, development of infrastructure, and broad economic growth, the industrial sector is necessary for the economy in Iraq. However, there is a problem of political instability, lack of infrastructure, and environmental challenges that have continuously hindered its potential, despite its significance (Al‒Ali, 2019; Mohamed et al., 2020). Factories and sectors like oil, petrochemicals, cement, and textiles have historically been dominated by state-owned enterprises. But the recent shift towards privatisation and economic liberalisation has enabled more private sector involvement. These efforts to adapt more sustainable development practices have enhanced economic and environmental performance (World Bank, 2020;Al-Waeli, Khalid, et al., 2020).

These efforts seek to minimize the ecological footprint of industrial activities and raise production and operational efficiency. So far, they are in line with the National Development Plan of Iraq, which stresses that sustainable industrial development is a major goal as part of it (Iraq Ministry of Planning, 2018). However, among these promising advances so far, many Iraqi industrial enterprises present great difficulties in realizing a systemic approach for sustainable development plans. The fundamental obstacles are insufficient access to new technologies, lack of funding for sustainability projects, and inexperience in sustainable management approaches (UNIDO, 2021;Mohamed et al., 2020).

Another complicating factor for enterprises to attempt to reach the international sustainable development standards is Iraq’s weak legislative framework for environmental standards and sustainability practices (Al-Ansari et al., 2020). Adopting sustainable development in the industrial expansion of Iraqi industrial companies, it is realized that our actions are not just temporary, it is likely on a very positive note to maintain the effort and progress. Inclusion of sustainable practices allows for environmental stewardship and may also enhance financial performance and enduring resilience to the cyclical ups and downs of Iraq’s unstable economic environment.

2.2 Sustainable Development

In today’s society Sustainable development is more critical than ever to meet economic development not just as a stand-alone issue, but in terms of social justice and environmental conservation. It includes numerous steps for ensuring that current progress does not hinder future generations' capacity to fulfil their demands. The Sustainable Development Goals (SDGs) (United Nations, 2015) of the United Nations serve as a clear framework to help the global initiative towards sustainable development and are 17 interrelated and common global goals to meet the major challenges that confront the world today comprising poverty, inequality, climate change, environmental degradation, peace and justice. In industry, sustainable development practices refer to approaches to minimize environmental impacts and enhance the economic and social benefits (Al-Salmawi & Rasheed, 2025).

One of the most important factors has shown up in Iraq and particularly in production industries is the importance of sustainability in development. In adversity from political crises to weak infrastructure, sustainable development means more than just reducing environmental harm it is also about economic robustness and enhanced social harmony. Adopting sustainable development as part of the Iraqi industrial policy is of fundamental concern for attaining a balance between economic development with environmental soundness and social responsibility (Al‒Ansari, 2020). This is the focus on sustainable development in industrial development that seeks to reconcile economic growth with environmental sustainability and social well-being. This integrative model guarantees long-haul sustainability and competitiveness of industries and supports global sustainability policies to serve generations to come (World Bank, 2021).

2.3 Financial Performance

Financial Performance is one of the main indicators of an organisation's general health and efficiency and thus ability to make a profit. This typically requires the monitoring of various financial indicators and ratios to understand if a company is using its assets effectively as well as efficiently managing its liabilities and enhancing earnings. Revenue growth, profitability, return on assets (ROA), return on equity (ROE), and earnings before interest and taxes (EBIT) are commonly mentioned as main performance indicators (Damodaran, 2007). Revenue growth can be an important proxy to show that sales are able to increase over a period of time. Market expansion, innovation of a product, and better consumer interest are the drivers of this expansion (Penman, 2010;Al-Waeli et al., 2020). To an organisation, it is an important sign of overall viability and success. Profitability (net and gross profit margin) indicates how profitable a company is in turning revenues into a visible profit (Brigham and Ehrhardt, 2013). Evaluating this set of financial performance parameters will enable investors, decision-makers and policymakers to have an impact in making decisions. It is also facilitated by knowing what is working, the areas that are more likely to be strong and which are still less likely to do a good job and providing action plans to grow and adapt in a dynamic business environment (Higgins, 2012; Sabour & Al-Waeli, 2023).

2.4 Artificial Neural Networks

Artificial Neural Networks (ANNs) are computer models meant to resemble the neural architectures of the human brain and are widely recognized to predict the ability of different systems to work together. They can identify patterns to account for shared points, process large volumes of data, and perform complex tasks in the same way the biological neurons that perform this task do. In the domain of financial performance and sustainable development, the tools provided by Artificial Neural Networks (ANNs) for data analysis, predictive modelling, and decision-making support are helpful (Haykin, 2009). Neural Networks have layers of interconnected nodes with their respective weight. They are built on massive datasets to learn and adjust weights through a backpropagation operation, to reduce errors and enhance their precision for instance.

Artificial Neural Networks (ANNs) are trained on data. They lead to their perfect fit in large and complex data like financial performance variables and sustainability evaluation (Goodfellow et al., 2016) or higher-level scientific concept. Predictive analytics is one of the key applications of artificial neural networks in finance. An ANN could conduct analysis of past financial data such that future performance can be formulated, trends can be identified and anomalies be uncovered. From a financial planning and risk management perspective, it does matter (Zhang, 2004). To understand the properties and abilities of an artificial neural network across many disciplines and through different environments is to demonstrate how this could be transformative, simultaneously in terms of financial and sustainability reporting. These are superior to traditional analytical methodologies to handle nonlinear interactions as well as big data and extensive datasets – resulting in more robust, better resilient and more flexible organisational strategies (Aggarwal, 2018).

Joint application of sustainable development model with financial performance and an artificial neural network has been regarded as a synergistic process. The use of artificial neural networks allows companies to review and refine green initiatives; the financial performances can improve as well. This symbiotic relationship illustrates the need for institutions to become open to new technologies if they seek to understand the modern corporate world and advance sustainable practices. Several theories guide the integration between sustainable development, financial performance and artificial neural networks through which financial performance and AI can be conceptualised: According to Stakeholder theory, value must be established for shareholders and the wider community, including workers, customers and suppliers (Freeman, 1984). It is inferred from this assumption that sustainable development initiatives should result in goodwill and loyalty to economic performance and financial value for stakeholders. Furthermore, businesses paying attention to eco-sustainable practices may enhance their image and the potential gain of loyal customers or sales by building clientele (Clarkson, 1995).

3. Methodology

Our research methodology includes several essential elements to systematically examine the correlation among sustainable development, financial success, and artificial neural networks (ANNs). We delineate the essential actions and procedures involved below:

3.1 Sample Selection

For this purpose, a representative sample of 20 Iraqi industrial firms that have publicly disclosed sustainability initiatives and financial performance indicators has been selected. This also guarantees a wide variety of industrial techniques and results across many industries to be included in the dataset. There are two major stages in this approach: the first step is to gather demographic data, while the second is to conduct a questionnaire with 254 participants. The questionnaire consists of questions about sustainable development as the independent variable (7 environmental; 5 economic, 5 social questions), financial performance questions as the dependent variable (7 questions), artificial neural network questions as the intermediary variable (9 questions).

3.2 Data Collection

Information is collected from a wide array of sources, including annual financial statements, sustainability reports, and external databases. Financial performance indicators (revenue, profitability, and return on assets) were then paired with sustainability indicators (carbon footprint, waste reduction, corporate social responsibility initiatives). Thus, historical data were gathered to form an in-depth temporal framework for analysis. Predictive models were constructed with trained artificial neural networks (ANNs) to predict financial performance that depends on sustainability initiatives. Corporate actors can evaluate the financial implications of their sustainability initiatives through scenario analysis using different simulated events. This study seeks out the relationships between sustainable development initiatives and new analytical tools like artificial neural networks (ANNs) to improve the financial performance of Iraqi industrial firms.

4. Results

It is established that sustainable development schemes are highly impactful on the financial performance of Iraqi industrial firms, with strong links with financial results in the analysis, and artificial neural networks have an important moderating impact on it. The findings also emphasise the importance of incorporating sustainable development practices for financial performance. The efficacy of artificial neural networks in predicting financial results has shown the way forward for accurate financial performance prediction, indicating the potential implications of using advanced analytical methodologies for strategic decision-making, as shown in Figure 1. Key indicators for measuring sustainable development.

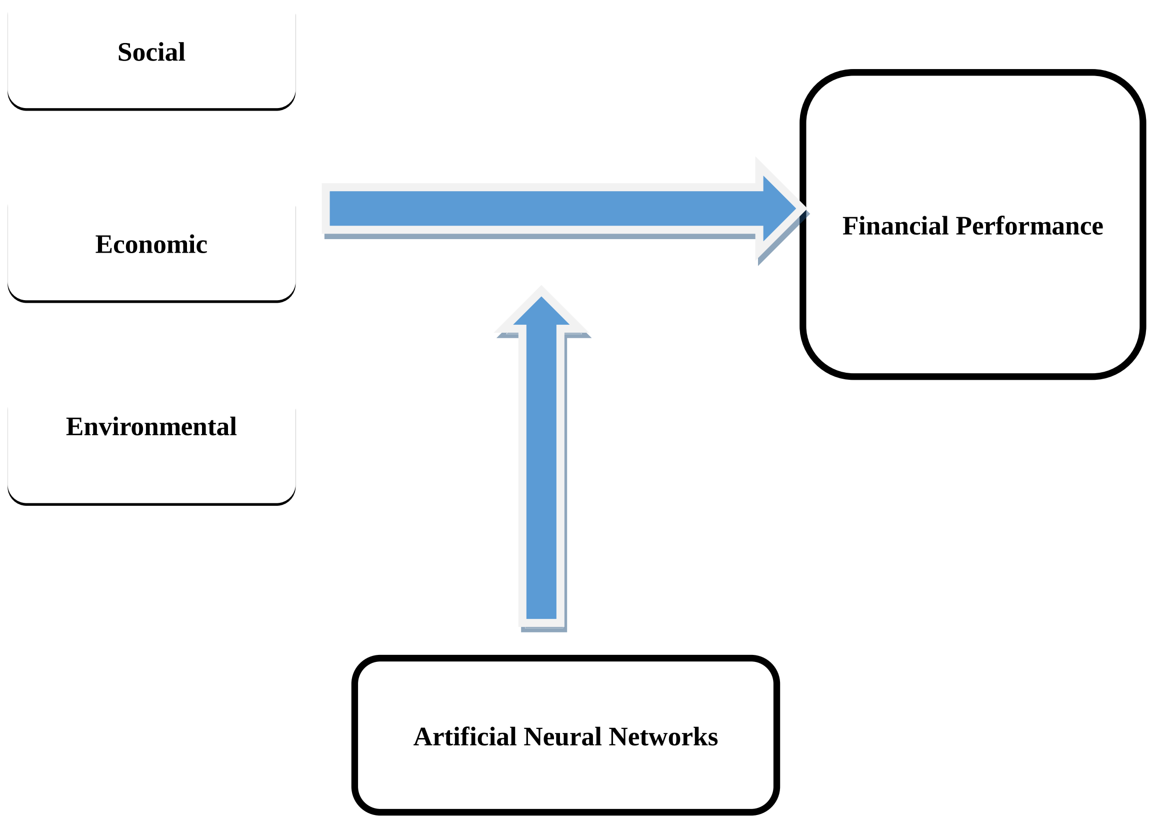


Figure 1. Key indicators for measuring sustainable development

Table1. Profile of Participant Demographics

		Count	Column N %
Age	1	6	2.4%
	2	63	24.8%
	3	99	39.0%
	4	28	11.0%
	5	58	22.8%
Education	2	44	17.3%
	3	191	75.2%
	4	6	2.4%
	5	11	4.3%
	6	2	0.8%
Experience	1	134	52.8%
	2	76	29.9%
	3	22	8.7%
	4	22	8.7%
c	1	35	13.8%
	2	61	24.0%
	3	76	29.9%
	4	82	32.3%

4.1 Validity and Reliability

The construction validity of the constructions was analyzed under standard configurations using the PLS method. Table 2 provides a detailed overview of reliability and convergent validity. Consequently, these results indicate that the Cronbach's alpha, composite reliability, and indicators all reach values above 0.7 and contribute to a higher reliability level toward this measurement model. Moreover, the average variance extracted (AVE) values are greater than 0.5, confirming convergent validity of the measures. Statements with composite reliability less than 0.7 and a variance inflation factor (VIF) greater than 10 (FP1) were removed Table 2.

Table 2. Overview of Tests for Reliability and Convergent Validity

Variables	Cronbach's Alpha	Composite Reliability	Meas_Items	Composite Reliability >0.7	Composite Reliability >0.7 after Del.	Average Variance Extracted (AVE) >0.5
			ANN1	0.94	0.94	
			ANN2	0.923	0.923	
			ANN3	0.879	0.879	
			ANN4	0.903	0.903	
ANN	0.976	0.979	ANN5	0.894	0.894	0.839
			ANN6	0.185		
			ANN7	0.918	0.918	
			ANN8	0.924	0.924	
			ANN9	0.946	0.946	
			ANN10	0.915	0.915	
			EC1	0.669		
			EC2	0.632		
			EC3	0.617		
			EC4	0.634		
EC	0.957	0.967	EC5	0.615		0.854
			EC6	0.796	0.796	
			EC7	0.947	0.954	
			EC8	0.946	0.956	
			EC9	0.942	0.952	
			EC10	0.945	0.953	
			EN1	0.957		
			EN2	0.93	0.938	
			EN3	0.854	0.855	
			EN4	0.951	0.953	
EN	0.950	0.956	EN5	0.916	0.924	0.733
			EN6	0.635		
			EN7	0.739	0.726	
			EN8	0.742	0.733	
			EN9	0.718	0.708	
			EN10	0.67		
FP	0.979	0.982	FP1	0.953		0.873

			FP2	0.946	0.95	
			FP3	0.904	0.897	
			FP4	0.915	0.922	
			FP5	0.917	0.92	
			FP6	0.128		
			FP7	0.94	0.94	
			FP8	0.939	0.941	
			FP9	0.951	0.952	
			FP10	0.953		
			SO1	0.617		
			SO2	0.595		
			SO3	0.568		
			SO4	0.571		
SO	0.950	0.962	SO5	0.01		0.834
			SO6	0.866	0.878	
			SO7	0.928	0.935	
			SO8	0.92	0.932	
			SO9	0.946	0.958	
			SO10	0.855	0.86	

4.2 Discriminant Validity

Discriminant validity was evaluated by the Fornell-Lacker criterion and the Heterotrait-Monotrait ratio (HTMT) criterion. Table 3 presents the results presented according to Fornell-Lacker's criterion in good form, such that diagonal entries represent the square root values of Average Variance Extracted (AVE) for different constructs. These measures consistently exceed other factors correlations and give more conclusive evidence of discriminant validity. The HTMT ratios in Table 4 all show values well below the selected cut off that has been defined (0.9). Henseler et al. (2015) argue that strict compliance with criteria for HTMT ratio ≤ 0.9 substantiates that there is discriminant validity in the framework.

Table 3. Outcomes of Fornell-Lacker's Criterion

	ANN	EC	EN	EP	SO
ANN	0.916				
EC	0.084	0.924			
EN	0.136	0.596	0.844		
EP	0.659	0.422	0.472	0.933	
SO	0.194	0.362	0.518	0.475	0.913

Table 4. Heterotrait-Monotrait Ratio (HTMT)

	ANN	EC	EN	EP	SO
ANN					
EC	0.083				
EN	0.135	0.574			
EP	0.675	0.428	0.435		
SO	0.197	0.367	0.508	0.487	

4.3 Structural Model Analysis

After verification of the measurement model, the hypotheses were examined using Partial Least Squares Structural Equation Modeling (PLS-SEM). Hair et al. (2017) indicate that route coefficients, the coefficient of determination (R2), effect sizes (f2), and the predictive value of Q2 were reported. Using SmartPLS 3 software, the researchers performed the bootstrapping technique at a resampling size of 5000 and evaluated the statistical significance of the route coefficient (Ramayah et al., 2018). The findings showed that all direct connections were statistically significant, so that the first five hypotheses (H1-H4) were accepted. A significant relationship between EC, EN, SO, and ANN with EP is shown in Table 5.

The results for H1 were $\beta = 0.28$, $t = 6.538$, $p < 0.000$, and $f^2 = 0.148$. The values for H2 were $\beta = 0.189$, $t = 3.639$, $p < 0.000$, and $f^2 = 0.063$. The values for H3 were $\beta = 0.135$, $t = 2.544$, $p = 0.011$, and $f^2 = 0.042$. The values for H4 were $\beta = 0.592$, $t = 13.614$, $p < 0.000$, and $f^2 = 1.137$.

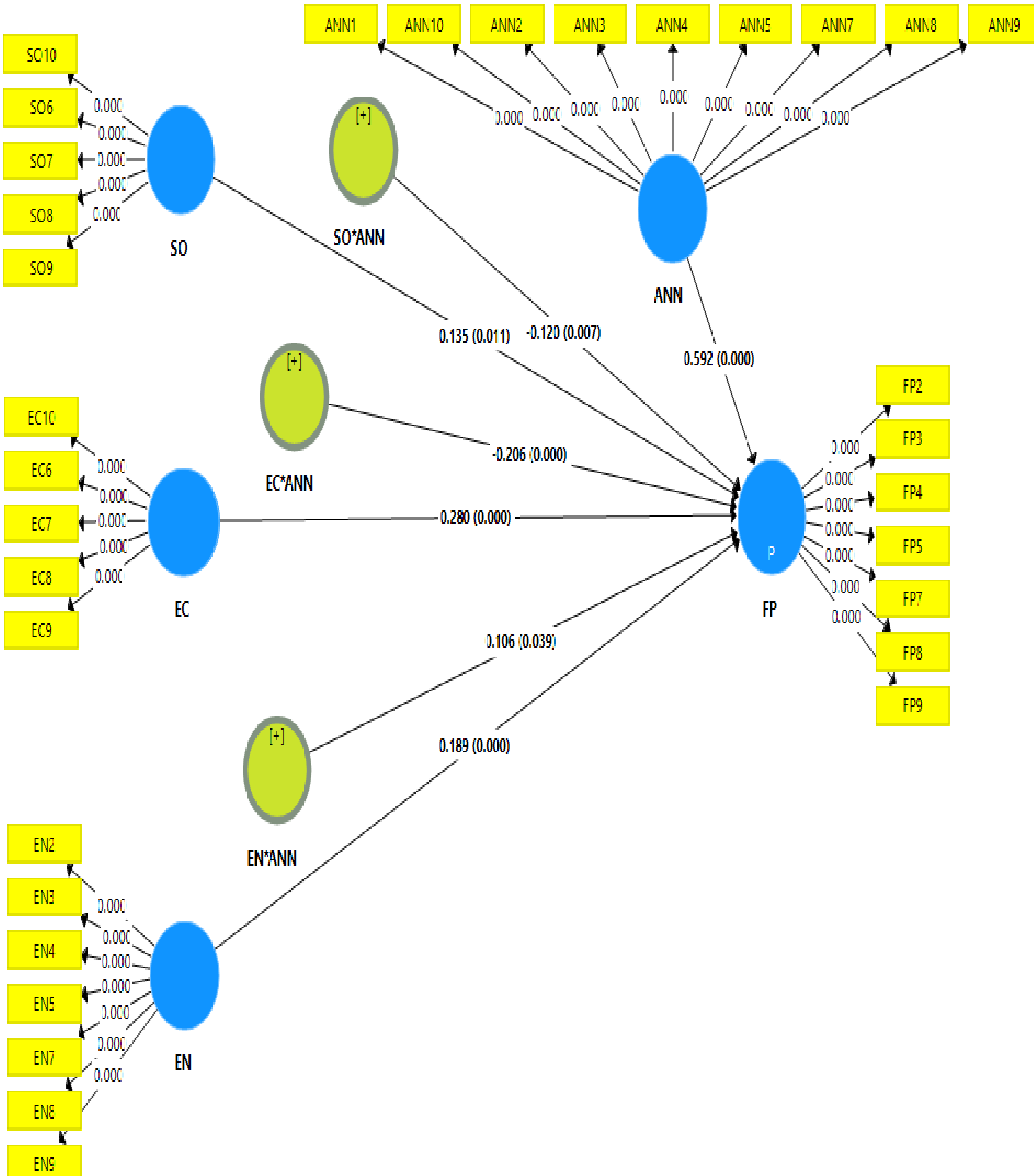
The analytical results demonstrate that ANN significantly improves EC, EN, SO, and EP relationships. The ANN exerted a substantial moderating influence on this connection, as evidenced by the statistical analysis in Table 5. This is supported by hypotheses H5, H6, and H7. Therefore, we have accepted hypotheses H5 (with a negative moderating effect), H6 (with a positive moderating effect), and H9 (with a negative moderating effect). The statistical results for these hypotheses are as follows: H5 ($\beta = -0.206$, $t = 3.882$, $p < 0.000$, $f^2 = 0.065$), H6 ($\beta = 0.106$, $t = 2.073$, $p = 0.039$, $f^2 = 0.025$), and H9 ($\beta = -0.12$, $t = 2.707$, $p = 0.007$, $f^2 = 0.028$).

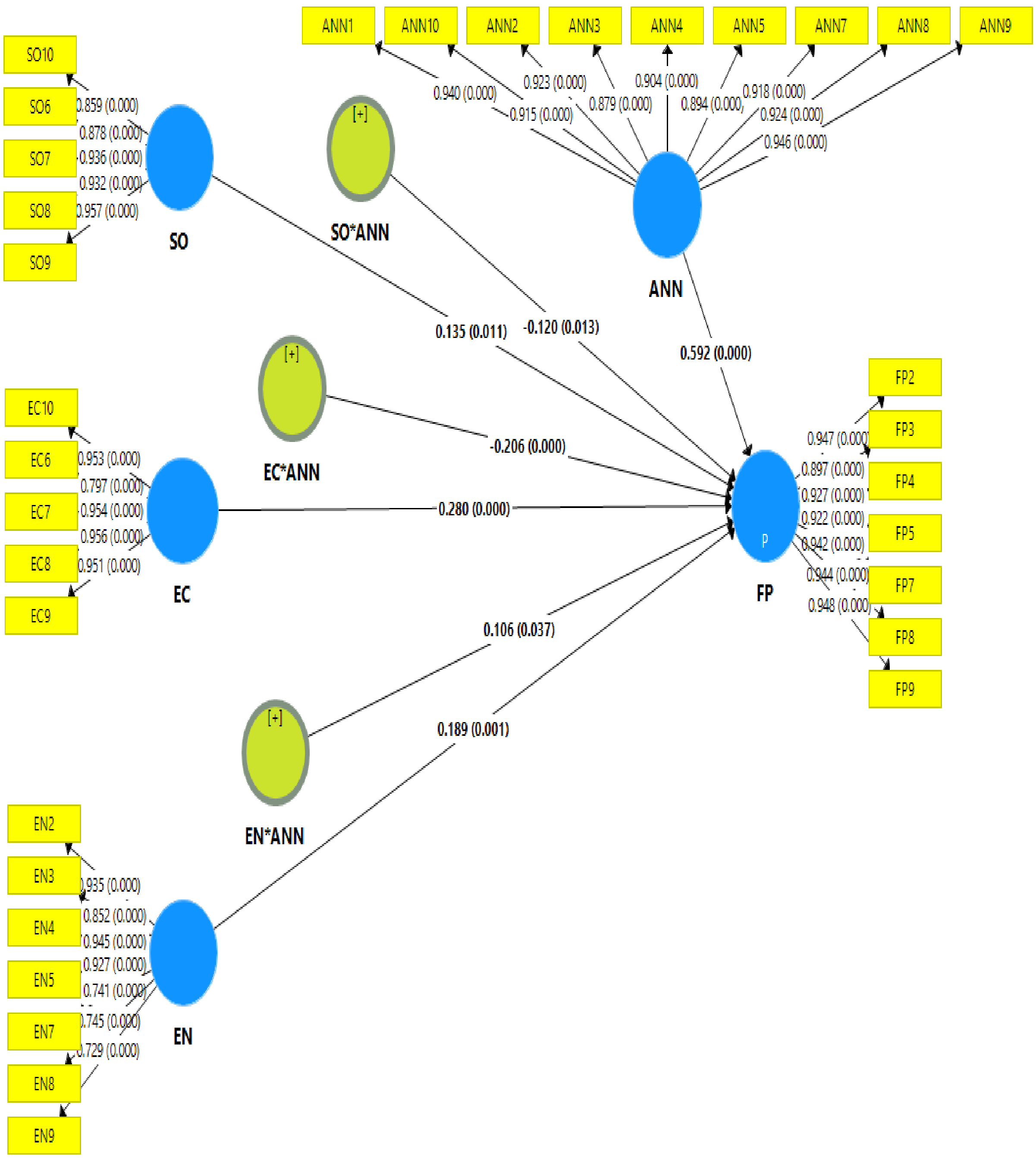
The value of R^2 ranges from 0 to 1, and the higher value of R2 determines the prediction accuracy. According to Chin (1998), R^2 values can be classified into three levels: intense (0.67), medium (0.33), and weak (0.19). The R^2 value was 0.707 based on the path coefficient analysis. A reflective endogenous latent variable is considered relevant in predicting a given construct when it has a positive Q^2 value (Hair et al., 2021). According to Table 5, the Q^2 value (0.609) was more than zero. Hence, the model possesses sufficient predictive efficacy.

Table 5. Bootstrapping Test Results

Hypo	Path	Beta (β)	Lower	Upper	T values	P Values	F^2	Remarks
H1	EC -> EP	0.28	0.21	0.373	6.538	0.000	0.148	Supported
H2	EN -> EP	0.189	0.093	0.301	3.639	0.000	0.063	Supported
H3	SO -> EP	0.135	0.021	0.234	2.544	0.011	0.042	Supported
H4	ANN -> EP	0.592	0.507	0.672	13.614	0.000	1.137	Supported
H5	EC*ANN -> EP	-0.206	-0.311	-0.102	3.882	0.000	0.065	Supported
H6	EN*ANN -> EP	0.106	0.007	0.204	2.073	0.039	0.025	Supported
H7	SO*ANN -> EP	-0.12	-0.211	-0.028	2.707	0.007	0.028	Supported

$R^2 = 0.707$, R^2 Adjust = 0.698, $Q^2 = 0.609$


ANN1
ANN10
ANN2
ANN3
ANN4
ANN5
ANN7
ANN8
ANN9
SO10
SO6
SO7
SO8
SO9
SO
SO*ANN
ANN
0.135 (0.011)
-0.120 (0.007)
0.592 (0.000)
EC10
EC6
EC7
EC8
EC9
EC
EC*ANN
-0.206 (0.000)
0.280 (0.000)
FP2
FP3
FP4
FP5
FP7
FP8
FP9
FP
0.106 (0.039)
0.189 (0.000)
EN*ANN
EN2
EN3
EN4
EN5
EN7
EN8
EN9
EN


ANN1
ANN10
ANN2
ANN3
ANN4
ANN5
ANN7
ANN8
ANN9
0.940 (0.000)
0.923 (0.000)
0.915 (0.000)
0.879 (0.000)
0.904 (0.000)
0.894 (0.000)
0.918 (0.000)
0.924 (0.000)
0.946 (0.000)
ANN
SO10
SO6
SO7
SO8
SO9
0.859 (0.000)
0.878 (0.000)
0.936 (0.000)
0.932 (0.000)
0.957 (0.000)
SO
SO*ANN
0.135 (0.011)
-0.120 (0.013)
0.592 (0.000)
EC*ANN
EC10
EC6
EC7
EC8
EC9
0.953 (0.000)
0.797 (0.000)
0.954 (0.000)
0.956 (0.000)
0.951 (0.000)
EC
-0.206 (0.000)
0.280 (0.000)
FP2
FP3
FP4
FP5
FP7
FP8
FP9
0.947 (0.000)
0.897 (0.000)
0.927 (0.000)
0.922 (0.000)
0.942 (0.000)
0.944 (0.000)
0.948 (0.000)
FP
0.106 (0.037)
0.189 (0.001)
EN*ANN
EN2
EN3
EN4
EN5
EN7
EN8
EN9
0.935 (0.000)
0.852 (0.000)
0.945 (0.000)
0.927 (0.000)
0.741 (0.000)
0.745 (0.000)
0.729 (0.000)
EN

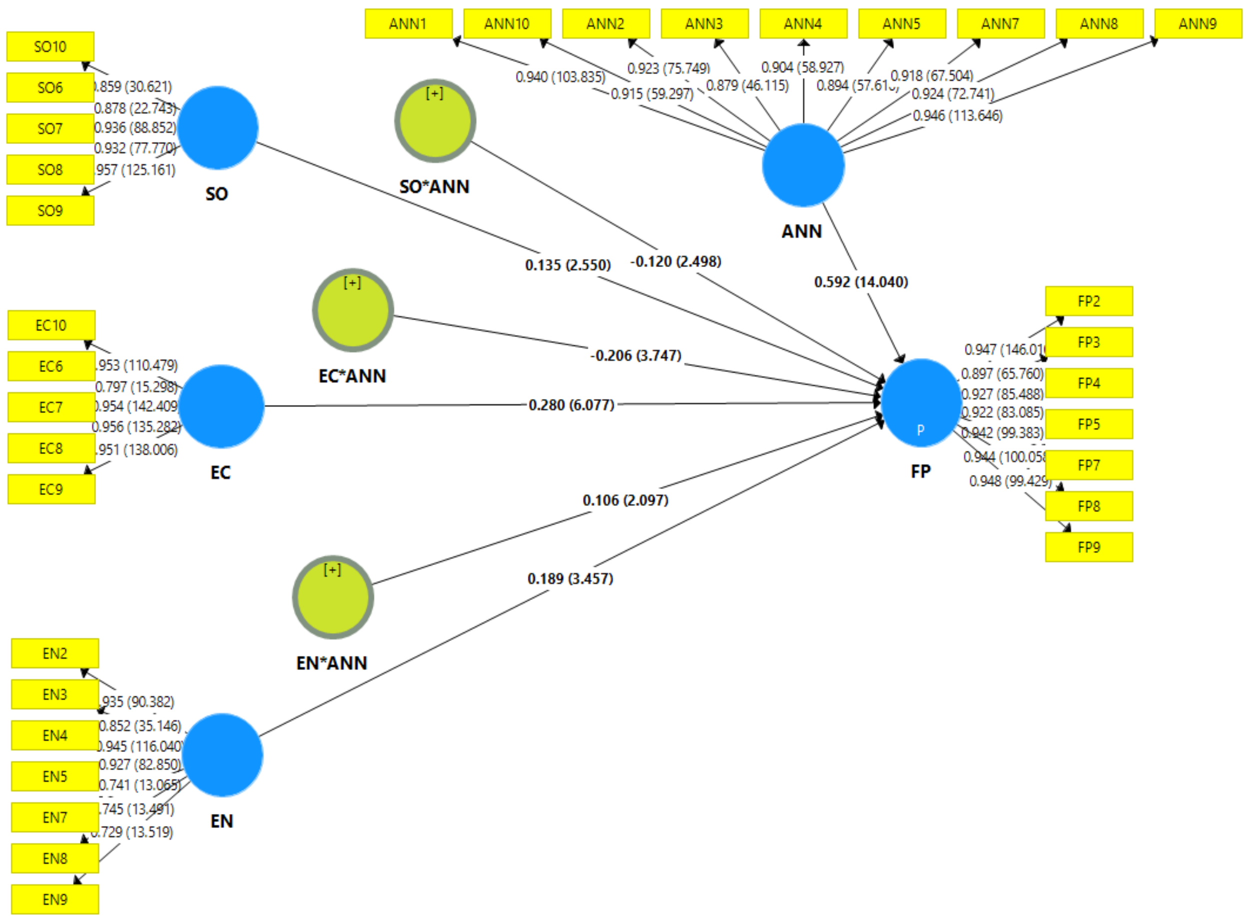


Figure 2. Bootstrapping Results

The present study utilized RMSE to evaluate the prediction capability of ANN. Table 6 shows that the average RMSE values for training and testing are 0.142 and 0.146, respectively. The results indicate that the (ANN) model in Figure 3 demonstrates high predicted accuracy and effectively matches the data (R2 = 0.856). The significance of reflecting independent variables in the ANN model can be comprehended by analyzing Table 6, which displays the count of synaptic weight connections to hidden neurons that are not equal to zero.

Table 6. RMSE Performance in Training and Testing Phases

Neural Network	ANN-Model (R^2= 85.6%)					
	Training Phase			Testing Phase		
	N-1	SSE	RMSE	N-2	SSE	RMSE
ANN-1	177	3.237	0.135	77	1.607	0.144
ANN-2	169	2.911	0.131	85	1.6	0.137
ANN-3	182	3.286	0.134	72	1.616	0.150
ANN-4	168	3.156	0.137	86	1.817	0.145
ANN-5	174	4.502	0.161	80	1.987	0.158
ANN-6	177	5.482	0.176	77	1.701	0.149
ANN-7	162	2.747	0.130	92	1.936	0.145
ANN-8	177	3.689	0.144	77	1.591	0.144
ANN-9	177	3.285	0.136	77	1.708	0.149
ANN-10	180	3.324	0.136	74	1.372	0.136
Average		3.562	0.142		1.694	0.146
Std.Dev		0.784	0.014		0.172	0.006

The results of a sensitivity analysis are given in Table 7, where individual significant predictors were ranked as normalized relative relevance (percentage values). Based on the relative importance of factors, the ANN was the most important predictor of EP (88%). Then came EN, EC, and SO at 78%, 74%, and 74%, respectively. The collective input from the neurons in Figure 3 and Table 7 provides more support.

Table 7. Sensitivity Assessment Using Normalised Importance Measures

Neural Network	In the ANN model, the output neuron represents EP			
	SO	EC	EN	ANN
ANN-1	0.088	0.221	0.223	0.468
ANN-2	0.181	0.132	0.242	0.445
ANN-3	0.195	0.198	0.201	0.405
ANN-4	0.09	0.139	0.261	0.509
ANN-5	0.152	0.181	0.125	0.543
ANN-6	0.147	0.149	0.157	0.547
ANN-7	0.163	0.19	0.203	0.444
ANN-8	0.135	0.107	0.272	0.487
ANN-9	0.148	0.141	0.222	0.49
ANN-10	0.153	0.175	0.214	0.458
Average Relative Importance	0.145	0.163	0.212	0.480
Maximum Relative Importance	0.195	0.221	0.272	0.547
Normalized-Relative Importance (%)	74%	74%	78%	88%

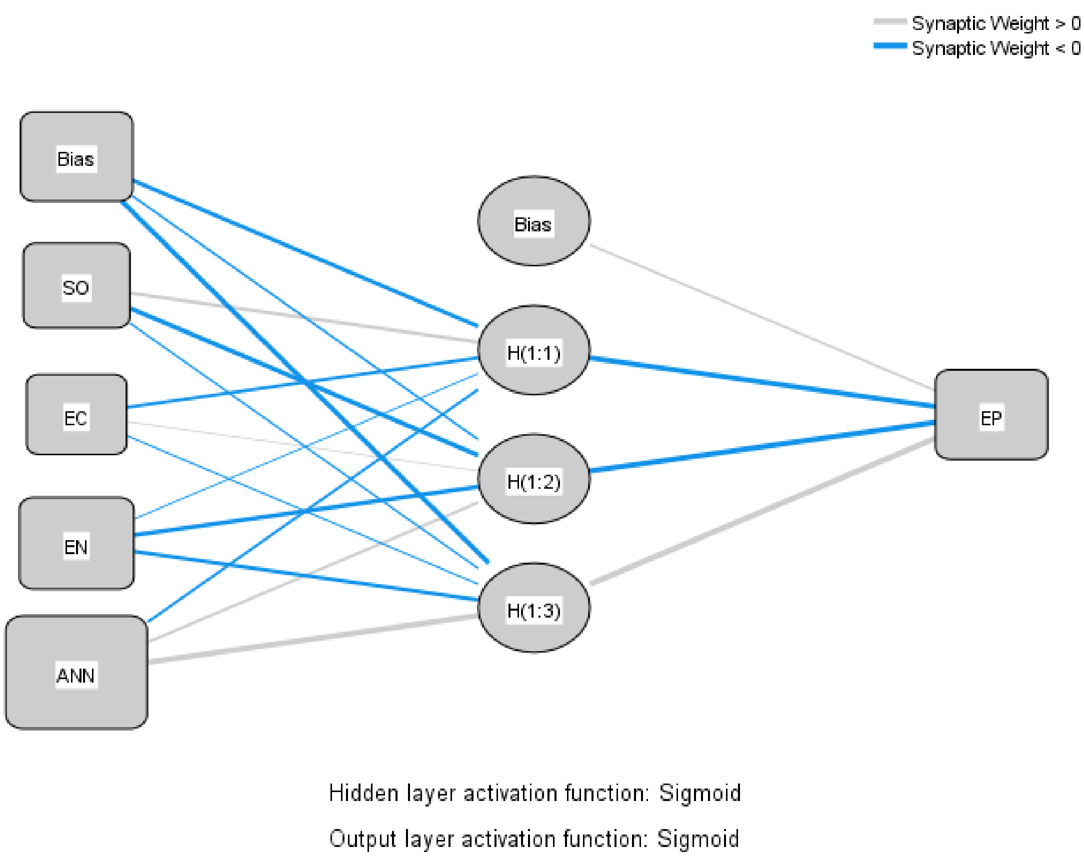


Figure 3. The ANN-2 Model

5. Discussions

In Iraqi industrial businesses, this paper found that sustainable development practices have a significant influence on the performance of companies. Artificial neural networks (ANNs) are used in the analysis; this was to capture complex, non-linear relationships that may not be captured by traditional statistical methods to achieve better understanding. It also appears that companies who are conscientious about taking ESG factors seriously, such as achieving higher sustainability goals, may be able also to capture positive side effects on the relationship between revenue, profit, and return on assets. Such an effect is significant for companies from the region of Iraq. This conclusion is in line with stakeholder theory and supports the evidence that many different stakeholders' interests will lead to financial benefits. Companies, for their part, might gain from operational efficiencies, reduced costs, and brand recognition, if they put sustainability first. The discussion generated some useful insights around differences in practices from industry to industry and how each of these impacts the activity. For example, manufacturing companies have got more out of sustainability investments, maybe because sustainability investments provide measurable gains in efficiency and waste reduction.

Conversely, smaller impact-generating organizations (e.g. notably, some service-based industries) had little improvement in their financials by achieving sustainability targets. ANNs are valuable in learning that helps in understanding the new data. In general, this research serves as an illustrative argument for two essential benefits sustainable development and cutting-edge analytics bring, thereby showing a route to sustainable and profitable financial success for industrial firms in Iraq and also other developing economies.

6. Conclusions

This study shows a positive and obvious correlation between the sustainable development practices and financial performance of Iraqi industrial companies, and we find artificial neural networks as significant moderating factor. Environmental, social and governance factors of sustainable development led to financial benefits of operational efficiency, improving reputation capital development & stimulating innovation. H1: EC -> EP: The path coefficient ($\beta = 0.28$) is positive and significant, implying that EC has a positive effect on EP. Strong support with T = 6.538, P = 0.000. It has F2 of 0.148. H2: EN -> EP: It has a significant path coefficient ($\beta = 0.189$), thus EN positively affects EP.

The T value is 3.639, and the P value is 0.000, indicating strong support. The effect size (F2) is 0.063. H3: SO -> EP: The path coefficient ($\beta = 0.135$) is positive and significant, indicating that SO positively influences EP. The T value is 2.544, and the P value is 0.011, indicating support. The effect size (F2) is 0.042. H4: ANN -> EP: The path coefficient ($\beta = 0.592$) is positive and significant, indicating that ANN positively influences EP. The T value is 13.614, and the P value is 0.000, indicating strong support. The effect size (F2) is 1.137. H5: EC*ANN -> EP: The path coefficient ($\beta = -0.206$) is negative and significant, indicating that the interaction between EC and ANN negatively influences EP. The T value is 3.882, and the P value is 0.000, indicating strong support. The effect size (F2) is 0.065. H6: EN*ANN -> EP: The path coefficient ($\beta = 0.106$) is positive and significant, indicating that the interaction between EN and ANN positively influences EP. The T value is 2.073, and the P value is 0.039, indicating support. The effect size (F2) is 0.025. H7: SO*ANN -> EP: The path coefficient ($\beta = -0.12$) is negative and significant, indicating that the interaction between SO and ANN negatively influences EP. The T value is 2.707, and the P value is 0.007, indicating support. The effect size (F2) is 0.028.

Also, Model Fit: R2 = 0.707: that the model explains 70.7% of the variance in EP. R2 Adjusted = 0.698: This adjusted number accounts for the number of predictors in the model. Q2 = 0.609: This means the model has a good predictive relevance. All hypotheses (H1 to H7) are accepted, where the variables are found to be significantly related to each other and interact to have an impact on EP. This study is evidence that the process of integrating sustainability into business operation in the business from a strategic perspective to serve the industry's success is strategically significant.

It enables businesses to meet their social responsibilities and generate measurable financial returns. The sophisticated artificial neural network technology is capable of uncovering complex patterns that are less clear to other methods and therefore, offers a far richer and clearer view of financial performance. More and more businesses do incorporate sustainability within their business culture for a strategic benefit beyond what is legally and morally expected, and a business necessity to be successful. The high-performance analytical tools such as AI-based neural networks, enable more accurate and informative predictions of sustainability data. These findings support a compelling case for industry leaders and governments to encourage and participate in sustainable practices and investments that lead to long-term economic and environmental resilience.

7. Future Studies

There are certain important ideas that future research should pay attention to, to develop our knowledge of the association of sustainable development, financial performance, and the role of artificial neural networks in industrial environments. Expanding the analysis to other types of businesses and different geographic areas could also lend greater validity to results. The effect of sustainability strategies on financial performance of emerging and mature economies could be compared and differences and parallels might be marked. Second, longitudinal studies would measure temporal changes over time, and thus the long-term impacts of sustainable development projects. Such studies could yield insights into the sustainability lifecycle and long-term returns in ESG (environmental, social and governance) impacts and investment opportunities. Further, future research should investigate the role of government legislation and regulatory systems to encourage or obstruct sustainability initiatives. Knowledge of the relationship of how policy frameworks interact with behavior of business would potentially guide public policymaking to ensure that the economy would develop sustainably. In such emphasis of such studies, future studies may improve understanding how investment makes an impact on the financial performance and could also supplement it with cutting edge approaches in future research.

References

Aggarwal, C. C. (2018). *Neural Networks and Deep Learning: A Textbook*. Springer.

Al-Ali, Z. (2019). The Challenges Facing Iraq's Industrial Sector. *Journal of Middle Eastern Economics*, *12*(3), 45-60.

Al-Ansari, N. (2020). Environmental Challenges and Solutions in Iraq. *Journal of Environmental Management, 255*, 109877.

Al-Ansari, N., et al. (2020). Environmental Challenges and Solutions in Iraq. *Journal of Environmental Management, 255*, 109877.

Al-Khafaji, R. (2022). Practical Implications of Sustainable Development in Iraq. *Iraqi Journal of Economic Reforms*, *6*(1), 34-50.

Al-Saadi, M., & Al-Ali, H. (2020). Industrial Sector Challenges and Sustainability in Iraq. *Middle Eastern Journal of Economics*, *10*(4), 123-138.

Al-Salmawi, M. A. K., & Rasheed, H. S. (2025). Analyzing cost accounting methods in light of technological development and their impact on managerial decision-making. *Anggaran: Jurnal Publikasi Ekonomi dan Akuntansi*, *3*(2), 24-42.

Al-Waeli, A. J., Ismail, Z., & Khalid, A. A. (2020). The Impact of Environmental Costs on the Financial Performance of Industrial Companies in Iraq. *International Journal of Management (IJM), 11*(10), 1955-1969.

Al-Waeli, A. J., Khalid, A. A., Ismail, Z., & And Idan, H. Z. (2020). The Relationship between Environmental Disclosure and Financial Performance of Industrial companies with Using a New Theory: Literature Review. *International Journal of Supply Chain Management*, *9*(5), 1078-1081.

Al-Waeli, A., Ismail, Z., Hanoon, R., & Khalid, A. (2022). The impact of environmental costs dimensions on the financial performance of Iraqi industrial companies with the role of environmental disclosure as a mediator. *Eastern-European Journal of Enterprise Technologies, 5*(13(119)), 43-51.

Al-Zubaidi, H. (2021). Sustainable Development and Financial Performance in Iraqi Industry. *Journal of Iraqi Development Studies, 5*(2), 45-67.

Brigham, E. F., & Ehrhardt, M. C. (2013). *Financial Management: Theory & Practice*. Cengage Learning.

Chin, W. W. (1998). The partial least squares approach for structural equation modeling. In G. A. Marcoulides (Ed.), *Modern methods for business research* (pp. 295–336). Lawrence Erlbaum Associates Publishers.

Clarkson, M. E. (1995). A stakeholder framework for analyzing and evaluating corporate social performance. *Academy of Management Review*, *20*(1), 92-117.

Damodaran, A. (2007). *Corporate Finance: Theory and Practice*. John Wiley & Sons.

Dyllick, T., & Hockerts, K. (2002). Beyond the business case for corporate sustainability. *Business Strategy and the Environment*, *11*(2), 130-141.

Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science, 60*(11), 2835-2857.

Freeman, R. E. (1984). *Strategic Management: A Stakeholder Approach*. Pitman.

Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2021). *Multivariate Data Analysis (8th ed.). Cengage Learning*.

Hassan, A., & Khalid, M. (2022). Sustainable Development Practices in Iraq: Progress and Prospects. *International Journal of Sustainability, 9*(2), 100-115.

Haykin, S. (2009). *Neural Networks and Learning Machines* (3rd ed.). Pearson.

Higgins, R. C. (2012). *Analysis for Financial Management*. McGraw-Hill/Irwin.

Iraq Ministry of Planning. (2018). *National Development Plan 2018-2022*. Government of Iraq.

Jasim, A., & Hussein, S. (2019). Sustainability Practices in Developing Economies: Evidence from Iraq. *International Journal of Business and Management, 14*(3), 89-105.

Khan, Z., & Shah, A. (2020). The Role of Artificial Neural Networks in Sustainability Studies. *Journal of Computational Economics*, *12*(2), 211-228.

Mohamed, K. A. S., Al-Waeli, A. J., & Rasheed, H. S. (2020). The role of disclosure of future financial information in maximizing the value of company in Iraqi industrial companies. *International Journal of Management (IJM), 11*(11), 337-349.

Mohamed, K. A. S., Al-waeli, A. J., & Rasheed, H. S. (2020). the Role of Disclosure of Future Financial Information in Maximizing the Value of Company in Iraqi. *International Journal of Management (IJM), 11*(November), 337-349.

Penman, S. H. (2010). *Financial Statement Analysis and Security Valuation*. McGraw-Hill Education.

Sabour, K. A., & Al-Waeli, A. (2023). The effect of Blockchain technology as a moderator on the relationship between big data and the risk of financial disclosure (analytical study in the Egyptian and Iraqi stock exchange). *Eastern-European Journal of Enterprise Technologies, 1*(13(121)), 132-142.

Trippi, R. R., & Turban, E. (1993). *Neural Networks in Finance and Investing: Using Artificial Intelligence to Improve Real-World Performance*. McGraw-Hill.

UNIDO. (2021). *Industrial Development Report: Iraq*. United Nations Industrial Development Organization.

United Nations. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. United Nations.

World Bank. (2020). *Iraq Economic Monitor: Navigating the Perfect Storm (Redux)*. World Bank Publications.

World Bank. (2021). *Iraq Economic Monitor: Navigating the Perfect Storm (Redux)*. World Bank Publications.

Zhang, G. P. (2004). *Neural networks in business forecasting*. IGI Global.