Prediction And Contribution of Electrical & Electronics (E&E) Industry Towards Malaysia Gross Domestic Product (GDP) By 2030

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Abstract. Malaysia's Electrical and Electronics (E&E) industry is pivotal, significantly contributing to national income through Gross Domestic Product (GDP), exports, and job creation. This industry is booming for drastic future expansion due to the Industrial Revolution, IR 4.0, and towards IR 5.0, with a high global demand for semiconductor chips from electric vehicles, artificial intelligence (AI), and other related sectors. Therefore, this study aims to predict the E&E industry sales value by 2030 and its subsequent contribution to GDP, which is crucial in future E&E infrastructure development and national economic planning of policy-making to fulfill the global demand. Six forecasting techniques were used: Decomposition, Holt-Winters Exponential Smoothing, Seasonal ARIMA (SARIMA), Time Series Regression, and Machine Learning (Artificial Neural Network and Support Vector Machine). The performances were evaluated using three error measures: RMSE, GRMSE, and MAPE. The findings indicated that the Time Series Regression model predicts a steady increase in Malaysia's E&E sales value and E&E industry GDP by 2030, indicating robust growth and significant economic contribution. By 2030, the E&E industry is expected to contribute over 8% to Malaysia's GDP, up from 7% in 2021. This aligns with the National Industrial Master Plan 2030, aiming for a 6.5% annual growth in the manufacturing sector, highlighting the E&E industry's pivotal role in driving economic growth.

Keywords: Electrical and electronics, Gross domestic product, Foreign direct investment, National industrial master plan 2030.

1 Introduction

The Electrical and Electronics (E&E) industry encompasses a broad range of products, including hardware, software, semiconductors, telecommunications gear, Internet of Things (IoT) devices, artificial intelligence (AI) technologies, and 5G equipment [1]. Global demand for semiconductor chips, driven by electric vehicles (EVs), solar panels, AI data centers etc., presents significant opportunities for Malaysia's E&E industry. Experts predict that the anticipated turnaround in the semiconductor market will benefit the global economy, with the AI semiconductor market projected to reach $119.4 billion by 2027 [2].

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Malaysia's participation in the E&E global value chain (GVC) has positioned the country as a significant player in the global E&E market. Over the past 30 years, Malaysia's exports have increased steadily, with the country accounting for a notable share of world E&E exports [3]. The E&E industry plays a substantial role in Malaysia economy, contributing significantly to GDP, exports, investments, and job creation. The country has made considerable progress since the Third Industrial Master Plan (IMP3) from 2006 to 2020, with the manufacturing sector playing a pivotal role by contributing about 24 percent to Malaysia's Gross Domestic Product (GDP) [4]. Specifically, in 2021, the E&E industry contributed 6.9% to Malaysia's GDP, amounting to RM 95 billion out of a total GDP of RM 1.39 trillion. Furthermore, in 2022, the sales values of the Electrical and Electronics (E&E) sub sector contributed 32% to the overall sales values of the manufacturing sector as compared to other sub-sectors [5] as shown in Figure 1.

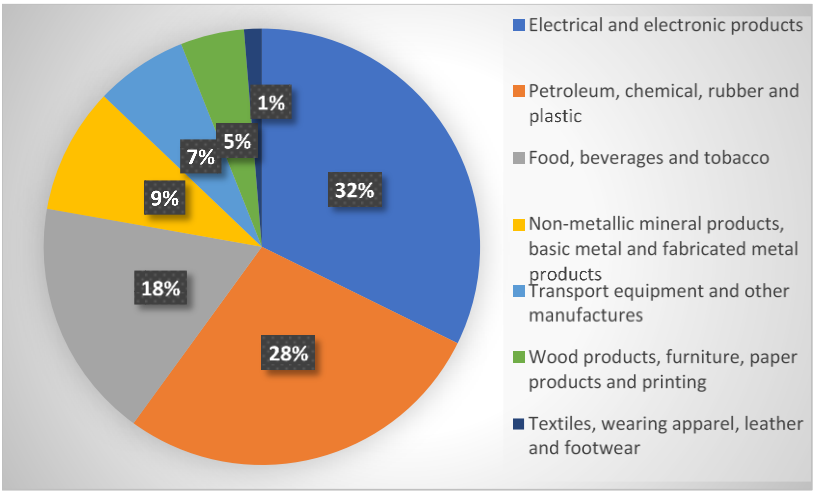

Fig. 1. Sales Values of Manufacturing Sector contributed by Sub-sectors in 2022 (DOSM)

The expansion of the Electrical and Electronics (E&E) industry is crucial to meet the rising global demand, especially with the transition towards Industrial Revolution 4.0 (IR 4.0). By embracing IR 4.0, the E&E industry can build smart factories that meet evolving customer demands with enhanced precision and flexibility, ensuring competitiveness in the global market [6]. However, the adoption of IR 4.0 technologies within the E&E industry remains uneven, with significant weaknesses in infrastructure, organizational support, and policies [7]. While some large firms, particularly multinational corporations (MNCs), have integrated advanced technologies, many small and medium-sized enterprises (SMEs) lag behind due to financial constraints and skill shortages [8]. Zhai et al. (2022) highlighted that delays in adopting IR 4.0 technologies could lead to a loss of competitiveness, as global players continue to advance rapidly in automation and digitalization [9]. This would make it difficult for Malaysian firms to meet

the evolving quality and efficiency standards required by international markets, potentially leading to a de-cline in market share and economic relevance.

Forecasting the sales value of Malaysia's Electrical and Electronics (E&E) industry and its contribution to GDP is crucial to understanding its role in Malaysia's economy, especially as the country prepares for Industrial Revolution 5.0 (IR 5.0) [10]. In essence, as E&E sales increase, so does its contribution to GDP. Forecasting helps identify trends in sales, enabling the Malaysian government to make informed decisions on technology adoption, resource allocation, and talent development [11]. Strategic forecasting not only prepares the E&E industry for IR 5.0 human-machine collaboration and sustainable production but also helps mitigate the risks associated with delayed IR 4.0 adoption [12]. Forecasts can guide investments in R&D, encourage upskilling of the workforce, and help implement policies that accelerate automation and digitalization, ensuring that Malaysia remains a top global player and continues to attract foreign direct investment (FDI) [13]. To successfully transition to IR 5.0, it is essential to upgrade the skills and digital infrastructure, which are critical for advanced technology adoption. Continuous training and education are crucial to equipping the workforce with the knowledge needed to operate in increasingly automated environments [12]. By integrating these technologies into production, Malaysia can maintain its competitiveness, drive economic growth, and prevent premature deindustrialization, all while aligning with the global shift toward smarter, more efficient manufacturing processes [6].

Therefore, this study aims to predict the sales value of Malaysia's Electrical & Electronics (E&E) industry and its contribution to GDP by 2030 aligning with the National Industry 4.0 Policy Framework (NIMP) 2030, which aims to facilitate the adoption of new digital technologies among businesses.

2 Methodology

This study employs secondary data on the monthly sales values of Electrical and Electronic products (E&E Sales Values), disaggregated by sub-sector, as well as quarterly GDP values contributed by the E&E industry (E&E GDP) and the overall GDP (Total GDP) across all economic sectors from 2008 to 2023. The data were sourced from the Department of Statistics Malaysia (DOSM). To ensure consistency with the quarterly GDP data, the monthly E&E Sales Values data were aggregated and converted into quarterly. This conversion was necessary to align both datasets for comparative analysis. In total, the study comprises 64 quarterly data points, with the first 56 quarters (Q1 2008 to Q4 2021) used for model estimation and the remaining 8 quarters (Q1 2022 to Q4 2023) designated for evaluation and validation of six forecasting techniques.

Six forecasting techniques were employed to predict the E&E Sales Values, E&E GDP, and the Total GDP of Malaysia. The forecasting techniques used include Decomposition, Holt-Winters Exponential Smoothing, Seasonal ARIMA (SARIMA), Time Series Regression, and Machine Learning techniques which were Artificial Neural Networks (ANN) and Support Vector Machine (SVM).

Decomposition

$$y_t = TR_t + SN_t + CL_t + IR_t \tag{1}$$

where TR_t, SN_t, CL_t, IR_t are trend, seasonal, cyclical, and irregular factor respectively.

Holt Winter Exponential Smoothing (HWES)

Level Equation

$$L_t = \alpha(Y_t - S_{t-m}) + (1-\alpha)(L_{t-1} + T_{t-1}) \tag{2}$$

Trend Equation

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \tag{3}$$

Seasonal Equation

$$S_t = \gamma(Y_t - L_t) + (1-\gamma)S_{t-m} \tag{4}$$

Forecasting Equation

$$\hat{Y}_{t+h} = L_t + hT_t + S_{t-m+h} \tag{5}$$

where
α: Smoothing parameter for the level ($0 < \alpha < 1$)
β: Smoothing parameter for the trend ($0 < \beta < 1$)
γ: Smoothing parameter for the seasonality ($0 < \gamma < 1$)
L_t: Estimated level of the series at time t
T_t: Estimated trend at time t
S_t: Estimated seasonal component at time t
Y_t: Actual value at time t
$\hat{Y}_{t+h}$: Forecasted value for h periods ahead
m: Length of the seasonal cycle

Seasonal ARIMA (SARIMA)

$$ARIMA(p,d,q)(P,D,Q)_s \tag{6}$$

where
(p,d,q) : The non seasonal part of the model
(P,D,Q)s : The seasonal part of the model
s: Number of periods per season

Time Series Regression (TSR)

$$y_t = TR + SN_t + \varepsilon_t \tag{7}$$

where

TR: the trend in time period t
SN_t: the seasonal factor in time period t
ε_t: the error term (irregular factor) in time period t

Artificial Neural Network (ANN)

$$y = f\left(\sum_{i=1}^{n} w_i\, x_i + b\right) \tag{8}$$

where
w_i: weights
x_i: input to neuron
b: bias

Support Vector Machine (SVM)

$$y = w * x + b \tag{9}$$

where
w: weights
x: input vector
b: bias

The performance of each forecasting technique was evaluated using three error measures: Root Mean Square Error (RMSE), Geometric Root Mean Square Error (GRMSE), and Mean Absolute Percentage Error (MAPE). The technique with the lowest error measures was selected as the best technique for predicting future E&E Sales Values, E&E GDP, and Total GDP by 2030.

Root Mean Square Error (RMSE)

$$\text{RMSE} = \sqrt{\frac{\sum_t^n e_t^2}{n}} \tag{10}$$

Geometric Root Mean Square Error (GRMSE)

$$\text{GRMSE} = \left(\prod_t^n e_t^2\right)^{\frac{1}{2n}} \tag{11}$$

Mean Absolute Percentage Error (MAPE)

$$\text{MAPE} = \sum_{t=1}^{n} \frac{|(e_t/y_t)*100|}{n} \tag{12}$$

where $e_t = y_t - \hat{y}_t$

y_t is the actual observation at the point t

$\hat{y}_t$ is the fitted of y_t

To estimate the contribution of the E&E industry to Malaysia's GDP by 2030, the predicted future value of the E&E GDP was divided by the predicted Total GDP for Malaysia in the same year. This percentage provided an estimate of the E&E industry's proportionate contribution to the overall GDP.

Contribution of E&E industry to GDP

$$\text{E\&E Percentage Contribution} = \frac{\text{Forecast of E\&E GDP}}{\text{Forecast of Total GDP}} \text{ x } 100 \quad (13)$$

3 Results and Discussions

Table 1, 2 and 3 shows the evaluation of six forecasting techniques based on three error measures: RMSE, GRMSE, and MAPE for E&E Sales Values, E&E GDP and Total GDP, respectively. Time Series Regression (TSR) performed best for predicting E&E Sales Values, as indicated by the lowest RMSE and MAPE values. However, the GRMSE value indicated SARIMA exhibited the lowest error. For the prediction of E&E GDP and Total GDP, Time Series Regression (TSR) consistently demonstrated the lowest error across all three error measurements (RMSE, GRMSE and MAPE), making it the most appropriate for predicting GDP values in both cases. This comprehensive evaluation highlights TSR as the superior technique for the prediction of GDP values, while SARIMA presents competitive results for E&E Sales Values when evaluated with GRMSE. Therefore, the TSR was utilized to predict the E&E Sales Values, E&E GDP, and Total GDP up to the year 2030.

Table 1. Comparison among techniques for E&E Sales Values

Techniques	RMSE	GRMSE	MAPE (%)
Decomposition	8,088	4,695	4.51
HWES	8,259	6,753	5.08
TSR	**6,905**	4,418	**3.81**
SARIMA	11,017	**3,680**	5.03
ANN	9,492	5,820	5.66
SVM	9,317	5,242	5.15

Table 2. Comparison among techniques for E&E GDP

Techniques	RMSE	GRMSE	MAPE (%)
Decomposition	5,792	5,562	18.43
HWES	2,377	1,966	6.95

TSR	**1,573**	**993**	**4.25**
SARIMA	1,859	1,280	5.17
ANN	1,946	1,674	5.92
SVM	2,614	1,966	7.50

Table 3. Comparison among techniques for Total GDP

Techniques	RMSE	GRMSE	MAPE (%)
Decomposition	76,006	73,010	16.43
HWES	30,824	28,469	6.54
TSR	**19,549**	**16,546**	**4.00**
SARIMA	56,624	48,910	11.65
ANN	59,682	55,290	12.68
SVM	52,835	48,495	11.16

Figure 2, 3 and 4 presents the actual and predicted values of E&E Sales Values, E&E GDP and Total GDP, respectively. A consistent upward trend in E&E Sales Values from Q1 2024 to Q4 2030, signaling a positive outlook for the E&E industry (Figure 2). This growth is crucial for sustaining Malaysia's economic development, as reflected in Figure 3, where the forecasted E&E GDP shows substantial expansion, with peaks typically observed in the first quarter of each year. This growth pattern highlights the E&E industry's pivotal role in driving economic progress, aligning with Malaysia's broader economic objectives. In contrast, the forecasted Total GDP for Malaysia, as shown in Figure 4, reflects a more gradual upward trend, suggesting that while the overall economy will grow steadily, the E&E industry as one of the sub sectors in manufacturing sector will outperform other manufacturing sub sectors in terms of growth rate.

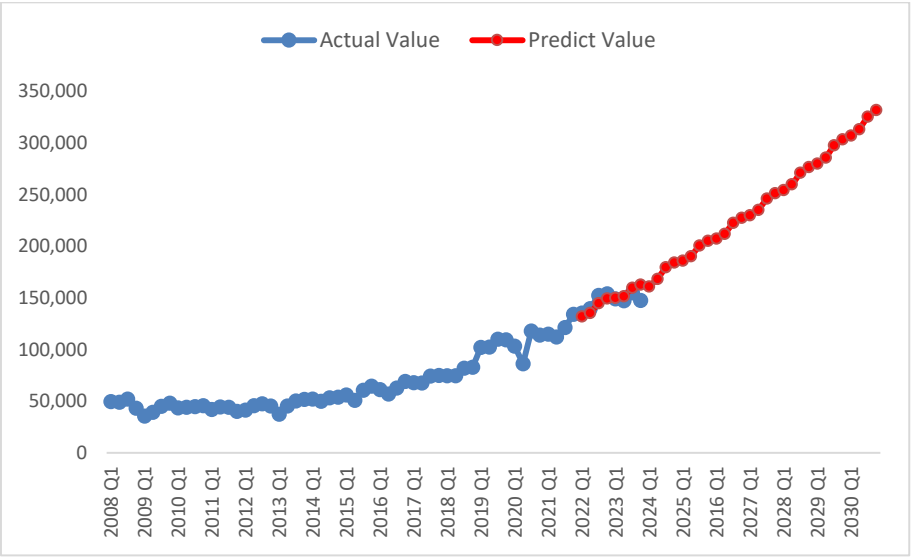

Fig. 2. Actual vs Predict of E&E sales value in RM Million

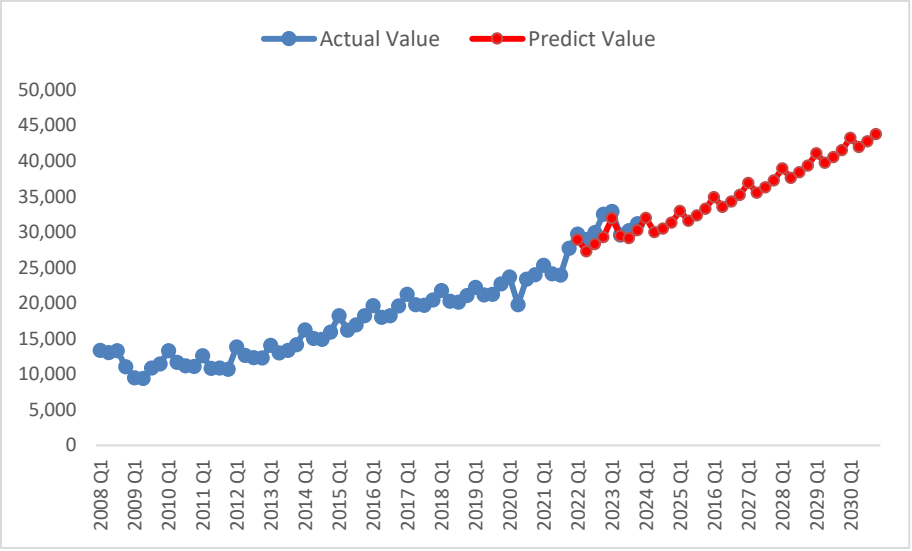

Fig. 3. Actual vs Predict of E&E GDP in RM Million

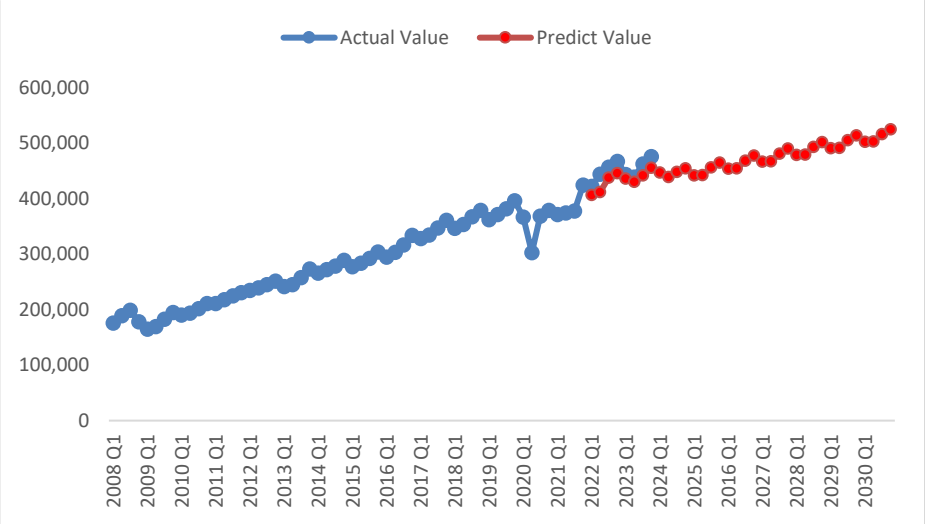

Fig. 4. Actual vs Predict of Total GDP in RM Million

By 2030, the E&E industry's contribution to Malaysia's GDP is projected to rise to over 8%, as depicted in Figure 5. This aligns with the National Investment Master Plan (NIMP) 2030's goal of achieving 6.5% annual manufacturing growth, with the E&E industry expected to contribute significantly with an annual GDP growth rate of 3.3%. This steady growth pattern highlights the industry's increasing economic importance and its potential to drive technological advancements and sustainable industrial practices as Malaysia prepares for IR 5.0. These forecasts emphasize the need for continued investment in digital infrastructure, talent development, and policy support to ensure the E&E industry can maintain its global competitiveness and meet evolving market demands.

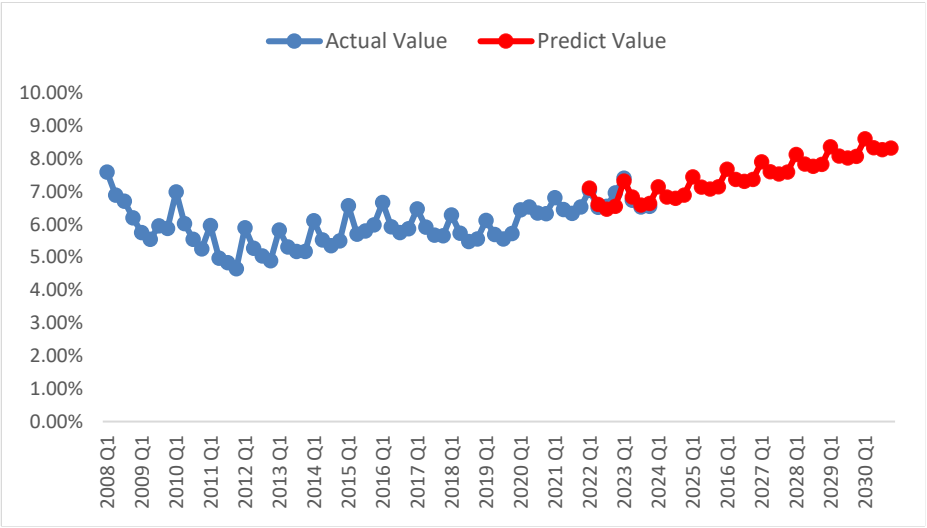

Fig. 5. Actual vs Predict of contribution of E&E to Malaysia's GDP in %

4 Conclusion

This study successfully achieved its aims in predicting the E&E Sales Values from Q1 2024 to Q4 2030 and demonstrating the consistent upward trend in Malaysia's Electrical and Electronics (E&E) industry. This growth highlights the E&E industry's potential to boost the overall export value of the manufacturing sector. Additionally, the study showed the significant contribution of the E&E industry to Malaysia's GDP, aligning with the New Industrial Master Plan's target of 6.5% annual growth in the manufacturing sector. The findings suggest that this projected growth will also attract increased foreign direct investment (FDI), further enhancing the E&E industry's output and economic impact.

This study provides valuable insights for policymakers, especially in terms of aligning future investments with Malaysia's National Semiconductor Strategy. This strategy aims to elevate Malaysia's role in the global technology value chain, with a focus on growing the semiconductor industry [14]. To support this growth, the government and companies must adopt Industrial Revolution 4.0 (IR 4.0) technologies, enhance infrastructure, and foster innovation. These efforts, coupled with a focus on sustainable practices, will ensure that Malaysia's E&E industry remains competitive and drives long-term economic growth.

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