



Developing a Model to Predict the Value of Thailand's Gem and Jewelry Exports Using Multiple Linear Regression Analysis

Anupong Sukprasert¹, Radyan Dananjoyo^{2*}, Jaruwan Supachaiwat³, Sutana Boonlua¹

¹ Mahasarakham Business School, Mahasarakham University, Maha Sarakham 44150, Thailand

² Department of Management, Universitas Muhammadiyah Yogyakarta, Yogyakarta 55183, Indonesia

³ Faculty of Business Administration and Accountancy, Roi Et Rajabhat University, Roi Et 45120, Thailand

Corresponding Author Email: radyan.dananjoyo@umy.ac.id

Copyright: ©2024 The authors. This article is published by IIETA and is licensed under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

<https://doi.org/10.18280/mmep.111219>

ABSTRACT

Received: 29 August 2024

Revised: 17 October 2024

Accepted: 23 October 2024

Available online: 31 December 2024

Keywords:

multiple linier regression, gems, jewelry, export values, United States of America, Thailand

This research aimed to develop a model to predict the export value of Thai gems and jewelry exports to the United States of America (US) by gathering secondary data and using multiple linear regression techniques for predicting the value of Thai gems and jewelry exports to that country. This industry has the third highest export value of Thailand's total export value. We collected daily data from January 1, 2020 to November 30, 2023, comprising 12 variables affecting the value of Thailand's gem and jewelry exports to the US. These variables included the exchange rates, US inflation rates, diesel prices in Thailand, US unemployment rates, gross domestic product (GDP), US consumer price index, average Thai labor wages, crude oil prices, Bank of Thailand's policy interest rate, gold prices, Purchasing Manager Index (PMI), and the Gem Price Index (GPI). The data were analyzed using the stepwise regression method to create a predictive model for the gems and jewelry export value. According to the results, the gold and diesel prices in Thailand were negatively significance related to the value of the Thai gems and jewelry exports to the US, which had a significant level of 0.05. The research results suggest to the government should enact laws that promote the export of Thai gem and jewelry by controlling the price of gold (implied as a material used in production) and diesel (implied as transportation system expense). These are two examples of policies that may be implemented to manage production and logistical costs. The research findings, which indicate the quantity of export value in the market, can be used by the government and gem and jewellery manufacturers to be more efficiently plan production and marketing to satisfy demand. The limitations and suggestions for future research are included in the latter.

1. INTRODUCTION

Thailand has faced significant threats since 2020 that could impede the revival of the economy. These issues have included the Coronavirus disease 2019 (COVID-19) pandemic, the conflict in Ukraine, inflation, and the significant rise in policy interest rates by central banks globally. The industrial sector has also been significantly impacted [1]. As such, this has led to a rise in the unemployment rate, which in turn has seen a decline in the economic growth rate and the per capita income. For example, the per capita consumption of gems and jewelry declined Thailand is now the 16th largest jewellery producer in the world thanks to its superb craftsmanship, which is firmly anchored in local knowledge and expertise. The gem and jewelry industry has been essential in supporting Thailand's economy in 2022, ranking third in terms of export value, following computers with accessories and automobiles and parts, respectively. When compared to the same period in 2021, the industry's export sales increased by 50.28% to almost USD 15,100 million. Gem and jewelry exports, excluding unwrought gold, totalled USD 8,036 million, a

30.29% increase. Thailand's gem and jewelry exports came in the ninth place. Furthermore, the sector has produced over 790,000 jobs across the supply chain, from manufacturing to retail and export. Thailand is now the 16th largest gem and jewelry producer in the world, which is firmly anchored in local knowledge and expertise [2].

In 2022, the COVID-19 pandemic diminished leading to the gradual recovery of several businesses. However, the presence of inflation and elevated unemployment rates still resulted in a state of economic stagnation [3]. The inflationary pressure in the market rose as a result of inadequate production of products and services to satisfy the consumer demand. In addition, in the absence of corrective measures by the government and the Federal Reserve, there was a risk of hyperinflation [4]. Furthermore, the Purchasing Managers Index (PMI) indicated a slowdown, and the reduction in output by the Organisation of the Petroleum Exporting Countries was expected to cause an increase in crude oil prices. Consequently, the United States of America (US)'s economy entered a technical recession [5]. This had a significant impact on the US economy resulting in a decrease in the purchasing

power of the people [6]. Hence, customers had a proclivity to postpone the consumption of luxury products and prioritized addressing unforeseen emergencies at a later time. The Thai gem and jewelry industry also continued to encounter significant trade restrictions that remain elevated [7].

In the midst of the worldwide economic deceleration, both the International Monetary Fund (IMF) and the Bank of Thailand have predicted that the Thai economy would have a growth rate of 3.7% in 2023 [8]. Moreover, the Bank of Thailand has anticipated that the world economy would not experience a recession due to the robust financial condition of the private sector. The labor market is also steadily improving [9], and the burgeoning economic recovery in the US is giving rise to lucrative business prospects. Due to its significant economic size, the US holds a prominent position in the global economy [10]. Whether it is related to consumption, the household sector, investment, or exports and imports, the high per capita income has led to a resurgence in the consumption of gems and jewelry. Additionally, the aforementioned elements have held great significance both domestically and among trading partners [11]. However, the gem and jewelry sector are undoubtedly impacted when the US experiences economic difficulties. Gemstones and jewelry have assimilated into the fabric of the American culture [12]. The US is likely to import many important Thai gem and jewelry products, including polished diamonds and gemstones, gold jewelry, silver jewelry, and artificial jewelry [12].

Nevertheless, the US saw a rapid recovery from the COVID-19 pandemic. This resulted in a surplus of demand within the economy. Nonetheless, this occurrence, which has resulted in the highest inflation rate in 40 years, has both positive and negative implications for businesses [13]. With the rising demand for gems and jewelry in the US, entrepreneurs might seize the chance to export a larger quantity of items. However, the persistent increase in inflation could lead to elevated prices for imported goods from Thailand in the future [14, 15]. Additionally, the US has become an important market for gem and jewelry industry exporting countries, including Thailand. Therefore, entrepreneurs must prepare a suitable strategy to enter the US market, especially focusing on consumer groups with purchasing power like Millennials [16] and exporters should plan production appropriately, so to be able to compete in the US [17]. Hence, it would be imperative to investigate the variables that could influence the value of gem and jewelry exports from Thailand to the US, as well as the specific manner in which they would impact these exports. Therefore, this research aimed to enhance the potential of the gem and jewelry export business.

In light of this issue, the researchers aimed to utilize the multiple linear regression analysis technique to develop a predictive model for the value of Thai gem and jewelry exports. Therefore, the key research question is “what the impact of economic factors on export value of gems and jewelry?” Additionally, the researchers intended to investigate the economic factors that could influence the value of gem and jewelry exports. The research findings on exporting Thai gems and jewelry would serve as valuable information for Thai traders in making informed decisions regarding marketing tactics. This would include formulating policies to promote the Thai gem trade in the global market.

2. RESEARCH OBJECTIVES

The general objective of this research is to examine the

impact economic factors on export value of gems and jewelry. The specific objectives of this research include:

To examine the level of the relationship between the economic factors that could affect the export value of gems and jewelry.

To investigate the economic factors that could affect the value of Thai gem and jewelry exports to the US.

To provide recommendations for Thai government policy makers who aim to enhance sustainable practices in the context of gem and jewelry industry.

3. LITERATURE REVIEW

Phittayanon and Rungreunganun [18] studied and analyzed the factors influencing the competitiveness of Thailand's silver jewelry industry using the analytical hierarchy process. Enhancing the export-oriented industry proved to be a formidable undertaking for achieving industrial competitiveness. The outcome indicated that the most crucial factors were sales and marketing drivers. As such, industries would be predominantly influenced by labor-intensive jobs, thus determining their competitiveness. Conversely, the research community could utilize the significance of the elements' weightage in order to conduct a study and formulate regulations that would foster the growth of the industry.

Phongphornworachai [19] examined the factors driving the competition that affected the competitive advantage and business success of the Thai gem and jewelry export industry. The results of the study found that the factors driving the competition overall influenced the competitive advantage in the Thai gem and jewelry export industry. The factors driving the overall competition influenced and affected the business success of the Thai gem and jewelry export industry, the overall competitive driving factors influenced and affected the business success of Thailand's gem and jewelry export industry, and the overall competitive advantage affected the business success of Thailand's gem and jewelry export industry.

Palma et al. [20] investigated the relationship between sustainable strategies and export performance. The work analyzed companies in Brazil in the gem and jewelry industry. The study's findings indicated that the exports of enterprises in the gem and jewelry industry were influenced by certain characteristics of sustainable development, as determined through the use of univariate and bivariate analysis on the data. The findings were consistently added to Brazil's favorable trade surplus annually. The growth of industrial enterprises that was expanding internationally in this industry was being influenced by ongoing changes.

Rastogi and Mwaitete [21] indicated a positive correlation between gold exports and the gross domestic product (GDP) of Tanzania. This implied that there was a positive correlation between gold exports and economic growth, such that an increase in gold exports was associated with an increase in economic growth, and a drop in gold exports was associated with a fall in economic growth. The outcome of R^2 was 81.75%, thus indicating the magnitude of the alteration in gold exports could have a significant impact on economic growth. Agricultural growth referred to the increase in agricultural value added, which measured the contribution of the agricultural sector to the overall economy. The public expenditure rate of increase in imports value added production referred to the increase in value that was created by various sectors, such as industry and government. This increase could

be measured in terms of revenue, reserves, and inflation.

Promkaew et al. [22] studied the economic factors affecting the value of Thai gemstone and jewelry exports to Switzerland. The analysis revealed a positive correlation between the price of gold and the value of Thai gem and jewelry exports to that country. A statistical significance level of 0.1 was observed in relation to the Consumer Price Index (CPI) of Switzerland and the price of diesel in Thailand. There existed a negative correlation between the value of Thai gem and jewelry exports and Switzerland. As such, they had a significant level of 0.05 and 0.1, respectively. The remaining variables comprised the actual GDP of Switzerland, and the interest rates on prime loans in Thailand and the exchange rate between the Thai Baht and US Dollar. There was no correlation between the value of Thai gem and jewelry exports and Switzerland.

In this research, we concentrate on the time-varying predictability brought on by economic impacts in factor-augmented forecasting models. As reported by Dananjoyo et al. [23], sample empirical evidence demonstrates that economic factors' predictability can be linked to the underlying economic dimensions.

4. RESEARCH METHODOLOGY

4.1 Data used in the research

Thailand's gem and jewelry industry has a significant influence on international supply chains and economic growth. Its sustainability has a major impact on a crucial economic factor, making a substantial contribution to GDP, exports, and employment. As a result, researching Thailand's gem and jewelry industry can offer valuable insights and experiences to the country's other manufacturing sectors.

In this research, the Gem and Jewellery Institute of Thailand provided the export value of Thai gems and jewelry for this research, while the Bank of Thailand (BOT) provided the exchange rate (EXTHB/USD), diesel prices in Thailand (POT), average labour costs in Thailand (THB), and the Bank of Thailand's policy interest rate (INT). The unemployment rate (UMP) is from Bureau of Labor Statistics. The gross domestic product (GDP/US) is from Bureau of Economic Analysis. While, the Consumer Price Index of Thailand (CPIUS) is from the US Bureau of Labor Statistics and the data

collected from the Federal Reserve Economic Data (FRED) is crude oil price USD/Barrel. The gold price (XAU/USD) is from the Gold Traders Association, the Purchasing Manager Index (PMI) comes from S & P Global Market, and the Gem Price Index (GPI) is from The Gem and Jewelry Institute of Thailand.

A model was created for forecasting the export value of gems and jewelry and studying the economic factors that affected the value of Thai gem and jewelry exports to the US. The researchers conducted research using secondary data stored in time series data. We collected daily data from January 1, 2020 to November 30, 2023, including 12 variables affecting the value of Thailand's gem and jewelry exports to the US (N=1430).

4.2 Variables used in the research

The variables obtained from reviewing past research were summarized as variables used in this research. This consisted of a dependent variable of the value of Thai gem and jewelry exports to the US, including 12 independent variables affecting the value of Thailand's gem and jewelry exports to the US (refer to Figure 1). These variables included the exchange rates, diesel prices in Thailand, US unemployment rates, US inflation rates, GDP, US consumer price index, average Thai labor wages, Thai central bank policy interest rates, crude oil prices, gold prices, PMI, gold price and Gem Price Index (GPI).

Data were collected from various websites and organizations to compile these variables (Table 1). This secondary data were time-series data recorded daily from January 1, 2020 to March 31, 2023, totaling 1,430 rows. The amalgamation of these variables formed the cornerstone for the predictive models, hence enabling the exploration of the complex relationships and facilitating an informed understanding of the factors influencing Thailand's gem and jewelry exports to the US.

4.3 Variables used in the research

Data preparation involved ensuring the accuracy and suitability of the data before using it for analysis and creating predictive models for the export values of Thai jewelry and ornaments.

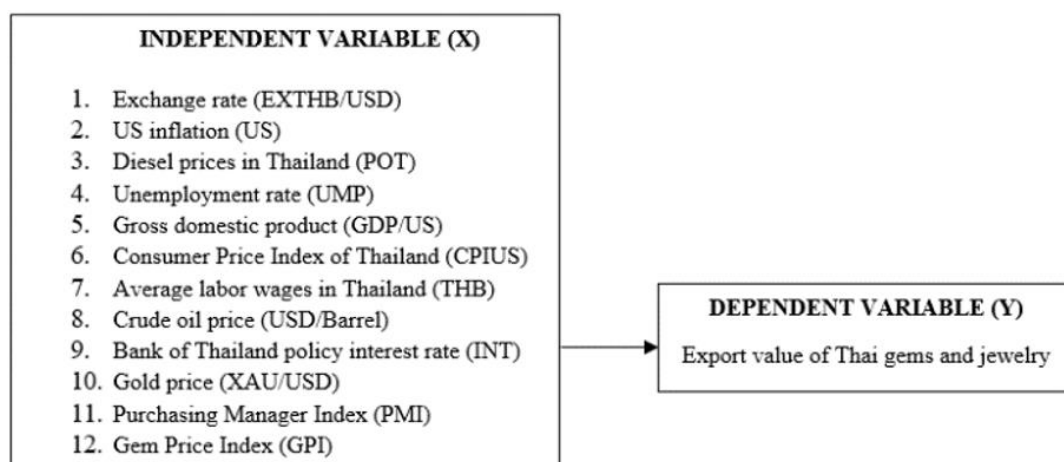


Figure 1. Independent and dependent variable

Table 1. Sources of secondary data for each variable

Variable	Source	Website
Export Value of Thai Gems and Jewelry	The Gem and Jewelry Institute of Thailand	https://git.or.th/th/home#gallery-popup-1
Exchange Rate (EXTHB/USD)	Bank of Thailand (BOT)	https://www.bot.or.th/Thai/Pages/default.aspx
US Inflation (US)	University of Michigan	https://th.investing.com/economic-calendar/michigan-inflation-expectations-389
Diesel Prices in Thailand (POT)	Bank of Thailand (BOT)	https://www.bot.or.th/Thai/Pages/default.aspx
Unemployment Rate (UMP)	Bureau of Labor Statistics	https://th.investing.com/economic-calendar/unemployment-rate-300
Gross Domestic Product (GDP/US)	Bureau of Economic Analysis	https://th.investing.com/economic-calendar/gdp-375
Consumer Price Index of Thailand (CPIUS)	U.S Bureau of Labor Statistics	https://th.investing.com/economic-calendar/cpi-733
Average Labor Wages in Thailand (THB)	Bank of Thailand (BOT)	https://www.bot.or.th/Thai/Pages/default.aspx
Crude oil price (USD/Barrel)	Federal Reserve Economic Data (FRED)	https://fred.stlouisfed.org/series/DCOILBRENTU
Bank of Thailand's Policy Interest Rate (INT)	Bank of Thailand (BOT)	https://www.bot.or.th/Thai/Pages/default.aspx
Gold Price (XAU/USD)	Gold Traders Association	https://www.goldtraders.or.th/
Purchasing Manager Index (PMI)	S & P Global Market	https://th.investing.com/economic-calendar/manufacturing-pmi-829
Gem Price Index (GPI)	The Gem and Jewelry Institute of Thailand	https://git.or.th/th/service/262/56

The integration of several economic factors—exchange rate, inflation rate, diesel price, unemployment rate, GDP, CPI, labor wage rate, crude oil price, interest rate, gold price, PMI, and GPI—is very important in the context of the Thai gem and jewelry business. The gem and jewelry industry are under growing pressure to adjust to quickly shifting global market, which can greatly boost its competitiveness. Adopting marketing agility can also help the government become a leader in the global market by allowing them to react quickly to changes in the market. In a world that is becoming more complex and interconnected by the day, the government can ensure sustainable growth and long-term success by enabling the gem and jewelry industry.

This process consisted of the following steps:

Step 1: The selection of the variables

The selection of the variables, used in the research as shown in Table 1, which was obtained from the literature review, was used to check the accuracy of the data (Data Validation) for each selected variable. This was conducted to remove any incomplete or duplicate information. and check for missing values (Missing Values) in case there were missing data in each attribute. This would also replace the missing data values (Replace Missing Values) with the average value of the data before the missing value. Three values and data behind the value were lost.

Step 2: Data integration

Data Integration: After preparing and completing the data in the first two steps, the researchers brought together all the variable data and saved the data file in an Excel file format for analysis with a statistical package in the next step.

4.4 Data analysis

The modeling for forecasting the value of Thai gem and jewelry exports to the US was based on quantitative data analysis by analyzing the form of a multiple linear regression equation to explain the relationship between the economic factors that affected the value of Thailand's gem and jewelry exports, along with examining the problems that would affect the equation. The resulting prediction was the problems of heteroscedasticity, autocorrelation, and multicollinearity.

5. DATA ANALYSIS

The researchers checked the preliminary agreement before analyzing the equation model. The researchers also checked the normality test. The statistics used for testing were the Kolmogorov-Smirnov test where Bland and Altman suggested that the sample size could be any number [24]. However, there should be more than 30 samples if a sufficient number of samples were to be collected. Consequently, the distribution of the said sample values would have normality. In this research, the number of samples used in this research was 1,430 and the relationship between all variables examined the correlation matrix results. Analysis of the Pearson's moment correlation coefficient of economic factors affecting the value of Thai gem and jewelry exports to the US was conducted (Table 2).

Table 2 displays the results of the relationship between the independent variables used to assess the economic factors that affected the value of Thai gem and jewelry exports to see if there were any multicollinearity problems or not. From the correlation, Devore and Peck suggested about the size of the correlation that if the correlation was high, the correlation value would be less than -0.80 or greater than 0.80, thus resulting in the correlation coefficient used in the estimation being inaccurate [25]. This is because it would be assumed that the independent variables being compared would be the same type of independent variable, consequently causing problems, so the multicollinearity would increase. The researchers checked the problem of linear relationship among the independent variables to see if they were at a high level again or not. In this research, the correlation matrix in Table 2 displays the relationship between the two variables ($r = 0.124$ to 0.153 , $p < 0.05$), which each pair of relations is lower than 0.80. By calculating the correlation values of the independent variables as shown in the Correlation Matrix, it was found that there was no correlation between any pairs of independent variables with values greater than 0.8, that is, the independent variables did not have a high degree of linear relationship with each other.

Table 2. Examination of the multicollinearity problems of the model

Variable	GJEV	EXT	US	POT	UMP	GDP	CPI	AVE	Oil	INT	Gold	PMI	GPI
GJEV	1												
EXT	-0.068	1											
US	0.028	-0.078**	1										
POT	0.153*	-0.088**	-0.041	1									
UMP	0.088	-0.012	0.008*	0.089	1								
GDP	-0.080	0.023**	-0.107	-0.081**	-0.112**	1							
CPI	0.045	0.009*	-0.028**	0.076	0.124*	-0.150	1						
AVE	0.033	-0.064	0.020**	-0.038**	0.019	-0.021	-0.077	1					
Oil	-0.022	-0.089	-0.001**	0.066	-0.050**	-0.008	0.230	-0.086	1				
INT	-0.056*	0.045**	-0.025	0.070	-0.041**	0.067	0.095	-0.067	0.335	1			
Gold	0.124*	-0.122*	-0.156**	-0.033	0.004*	0.099	-0.352**	0.036**	-0.042	-0.046	1		
PMI	-0.031	-0.046	0.006	0.018	0.114	-0.137	0.214	-0.084	-0.219	-0.024	0.013	1	
GPI	0.118*	0.107	-0.001	0.142	-0.009	0.045	-0.128*	0.195	0.012	0.065	0.003*	-0.249**	1

** Statistically significant level of 0.01, *Statistically significant level of 0.05.

5.1 Create a multiple regression model

For creating a model for forecasting the value of Thailand's gem and jewelry exports using the method of adding the independent variables in a stepwise regression, the results of creating a multiple regression model from using all the data on the dependent and independent variables were utilized to create it. The multiple regression model predicted the value of Thai gem and jewelry exports to the US. Furthermore, when testing the assumptions of all twelve independent variables to see if they were related to the dependent variable or not, the main hypothesis was that the twelve independent variables did not have a linear relationship with the dependent variable ($H_0: \beta_1=\beta_2=\beta_3=\dots\beta_{12}=0$). This was in contrast to the secondary hypothesis that there would be at least one independent variable that had a linear relationship with the dependent variable (H_1 : There is at least one value of β_j that is not equal to 0; $j=1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12$). The test statistic F was used to check the appropriateness of the model (Table 1).

5.2 Checking the preliminary agreement of the multiple regression model

Checking the multiple regression model to see if it met the preliminary agreement or not in order to ensure the accuracy and reliability of the model was conducted as follows:

-Checked whether a sample of data has a normal distribution, the Kolmogorov test statistics is used to check if the discrepancies were normally distributed [24]. It has been verified that the analysis's data passes the normality test.

-Checked the variance of the error using White's General Test Statistics (Eq. (8)) [26], the white test value was 5.38 and the Obs.*R-squared was 0.613, both of which are higher than 0.05. The heteroscedasticity is therefore absent.

-Checked the independence of the tolerances uses the Durbin-Watson test [27], the Durbin-Watson test value is 2.009. This means the residuals from a linear regression model are independent.

-Examined the co-linearity of the independent variables (Multicollinearity) in which each independent variable would be independent by considering the variance inflation factor (VIF) [28], the VIF is 1.005 which is less than 10. This means there is no multicollinearity issue.

-Measured the suitability and accuracy of the regression model based on the mean absolute deviation (MAD), the mean squared error (MSE), and mean absolute percent error

(MAPE) values [29], which had the following analysis results. The value of MAD is 4.15, MSE is 20.34, and MAPE is 19.76%. This indicates that the regression model's accuracy rate is acceptable.

Regression analysis

$$e_i^2 = b_0 - b_1X_{1i} + b_2X_{2i} + e_i$$

$$\text{NewY}^2 = b_0 + b_1\text{Gold} + b_2\text{POT} + e$$

Regression analysis

$$e_i^2 = \alpha_0 + \alpha_1X_1 + \alpha_2X_2 + \alpha_1X_1^2 + \alpha_2X_2^2 + \alpha X_1X_2 + v_i$$

$$\text{NewY}^2 = \alpha_0 + \alpha_1\text{Gold} + \alpha_2\text{POT} + \alpha\text{POT} + V_i$$

Hypothesis

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = 0 \text{ (Homoscedasticity)}$$

$$H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq 0 \text{ (Heteroscedasticity)}$$

Table 3. Problem verification of heteroscedasticity using White's General Test

White's General Test
R – Square = 0.053823 F-statistic = 1.336
White test = 5.38 Obs*R-squared = 0.613

*Statistically significant level of 0.05

Table 3 shows the result of the problem of heteroscedasticity. By considering the value Obs*R-squared at the statistical significance level of 0.05, it was found that the Obs*R-squared value was equal to 0.613, which was greater than 0.05. This inferred that this equation did not suffer from the problem of heteroscedasticity. Moreover, this was consistent with the concept of Devore and Peck [25] who introduced the decision criteria that if Obs*R-squared was greater than 0.05, there was no problem of heteroscedasticity.

Table 4 displays the results of the problem of the linear relationship between the error values. This was tested by estimating the least squares multiple regression equation by considering the statistical values. Durbin-Watson (DW) statistics were used for the criteria for the measurement [27]. DW had to have a value in the range of 1.5-2.5 to indicate independence. From Table 4, it was found that the DW value was equal to 2.009, which was greater than 1.5 and less than 2.5, thus indicating that there were autocorrelation of Durbin and Watson [27].

Table 4. Problem verification of autocorrelation using the Durbin-Watson statistic

Variable	Unstandardized Coefficients		t-Test	p-Value
	B	Std. Error		
(Constant)	421.568	17.020	24.769	0.000*
Gold	-0.001	0.000	-3.371	0.001*
POT	-0.846	0.383	-2.206	0.028*

F = 8.673; Sig. = 0.000*

R = 0.627; R Square = 0.393; Adjusted R² = 0.376

Durbin-Watson = 2.009

*Statistically significant level of 0.05.

Table 5 displayed the results that the economic factors affected the value of the Thai gem and jewelry exports. The results had a statistically significant level of 0.05 (F = 8.673; Sig. value = 0.000), which inferred that there was at least one independent variable that had a significant influence on the dependent variable at the level of 0.05. The factors affecting the value of Thai gem and jewelry exports to the US (million THB) included the price of crude oil, foreign currency exchange rates, and the average labor wage of Thailand. These issues affected the changes in the value of Thai gem and jewelry exports to the US (37.6 million THB; Adjusted R² = 0.376). Other than that, there were other factors that were not studied. The multiple correlation coefficient (R) was equal to 0.627, and the expected movement values were independent of each other (Autocorrelation). By considering the DW statistics, they were found to be equal to 2.009, which had a

value greater than 1.5 and less than 2.5. This indicated that there were independent expected values (Autocorrelation) that were consistent with the concept of Durbin and Watson (1950, 1951). When considering the VIF value, there was a value 1.005, which had a value less than 10 [28] and the tolerance statistic of the variables had a value 0.995, which was not close to zero [29], thus indicating that all independent variables were not highly related. This assumed that the level of relationship among all independent variables did not cause a problem. Multicollinearity and the confidence interval of the forecast equation (lower bound-upper bound) b1 was between (-0.002; -0.001) and b2 was between (-1.599; -0.093).

The collection of secondary data was in the form of a time series (Time Series) where the data changed over time. Therefore, the researchers had to check the measurement of the error between the actual and predicted values using various coefficients or the amount of various information. As such, it was determined that the actual value was closest to the forecast value or caused the least amount of error to obtain the most appropriate forecasting equation. This was measured by various values consisting of the MAD equal to 4.15, MSE equal to 20.34, and MAPE equal to 19.76%, which had a good level of forecast accuracy. This was consistent with Lewis's criteria for evaluating the accuracy level of forecasts, which stated that a MAPE value between 10-20% was considered a good level of forecast. Additionally, from studying the relationship above, it was found that some independent variables were not in a linear relationship. This could be expressed in the following final forecast equation.

Table 5. Test results using multiple linear regression analysis

Variable	Unstandardized Coefficients		t-Test	p-Value	95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error			Lower Bound	Upper Bound	VIF	Tolerance
(Constant)	421.568	17.020	24.769	0.000*	388.150	454.986		
Gold	-0.001	0.000	-3.371	0.001*	-0.002	-0.001	1.005	0.995
POT	-0.846	0.383	-2.206	0.028*	-1.599	-0.093	1.005	0.995

F = 8.673; Sig. = 0.000*

R = 0.627; R Square = 0.393; Adjusted R² = 0.376

Durbin-Watson = 2.009

MAD = 4.14; MSE = 20.34; MAPE = 19.76%

*Statistically significant level of 0.05.

$$\hat{Y} = b_0 + b_1\text{Gold} + b_2\text{POT} + e$$

$$\hat{Y} = 421.568 - 0.001\text{Gold} - 0.846\text{POT} + e$$

6. RESEARCH RESULTS

The results found that the prices of gold and diesel in Thailand were related to the value of Thai gems and jewelry exports. This also had a statistically significant level of 0.05 with the details as follows:

(1) The price of gold had an inverse relationship with the value of Thai gem and jewelry exports to the US. This had a statistically significant level of 0.05 that was the coefficient of the gold price with a value of -0.001. This indicated that when the gold price changed by one unit (XAU/USD), this would cause the value of Thai gem and jewelry exports to the US to decrease by 0.10%. This is consistent with the findings of Palma et al. [20], who proposed that the performance of jewellery exports is influenced by the gem and jewellery industry. This, however, the findings of Promkaew et al. [22], who found a positive relationship between the value of Thai gem and jewellery exports to European nations and the price

of gold.

(2) The price of diesel in Thailand had an inverse relationship with the value of Thai gem and jewelry exports to the US. This had a statistically significant level of 0.05 that was the coefficient of the Gem Price Index with a value of -0.846. This indicated that when the Gem Price Index changed by one unit (XAU/USD), this would increase the value of Thai gem and jewelry exports to the US to decrease by 84.6%. The price of diesel affects the cost of exporting Thai gem and jewelry industry. Because of this, shipping items overseas is now less expensive, which will raise the value of Thai gem and jewelry exported. This result is consistent with statement that export capacities can be improved by lowering transportation and infrastructure costs for exporters or manufacturers [30].

(3) The exchange rate, inflation rate, unemployment rate, GDP, CPI, labor wage rate, crude oil price, interest rate, PMI, and Gem Price Index (GPI) have no significant relationship with export value of Thai gem and jewelry. This is consistent with Phongphornworachai's [19] study which found that the gem and jewelry industry has not benefited from low labor wage rate or any unemployment rate. The results contradict with Phittayanon and Rungreunganun [18] who suggested that

labour-intensive employment would have a greater impact on the competitiveness of the gem and jewellery industry.

The findings [21, 22] suggested that the Consumer Price Index (CPI), actual GDP, interest rates on prime loans, the exchange rate between the Thai Baht and US dollar all had not significant impact on the value of Thai gem and jewelry exports to Switzerland.

The results found that the factors affecting the value of Thai gem and jewelry exports to the US included the gold and diesel prices in Thailand. This inferred that when there was a change in these two factors, the value of the exports would be affected. Exporting Thai gems and jewelry to the US changed, while the exchange rates, US inflation rates, US unemployment rates, GDP, US CPI, average Thai labor wages, crude oil prices, Bank of Thailand's policy interest rate, PMI, and GPI had no relationship with the value of Thai gem and jewelry exports to the US.

7. DISCUSSION

This research studied the modeling for forecasting the export value of gems and jewelry in Thailand by using multiple linear regression techniques. The results of this research are discussed as follows:

(1) Gold prices had an inverse relationship on the value of Thai gem and jewelry exports to the US. When the price of gold increased by one unit (XAU/USD), the value of Thai gem and jewelry exports to the US would decrease by 0.60%, which was in line with the research of Rastogi and Mwaitete [21]. Gold exports rose with increased economic growth and when gold exports decreased, economic growth also tended to decrease. This explained that gold played a very important role in the gem and jewelry market. When the population's demand for gold increased, gold would become an important trade item. The US is also a major economic power in the world. Whether gold prices, consumption, investment, and/or exports and imports, there was a high income per capita, and the US was very popular in consuming luxury products [30]. As a result, gems and jewelry have become a part of American culture, thus making the US an important market. When the US has economic problems, gold prices affect the industrial sectors at home and abroad. This also includes the fluctuating price of gold, as the prices may cause the country to lose its gold prices competitiveness or reduce the value of gem and jewelry exports. This would continue to affect the wages of workers involved in the gem and jewelry industry, which could inevitably be affected by exports to the point of slowing down the economic expansion [10, 16]. Therefore, sustainable strategies would need to be adopted to maximize the benefits of export performance of companies in the gem and jewelry industry [20].

(2) Diesel prices in Thailand were related in the same direction to the value of Thai gem and jewelry exports to the US. When the GPI increased by one unit (Thai Baht per US Dollar), the value of Thai gem and jewelry exports to the US would decrease by 0.846%, which was consistent with the research of Promkaew et al. [22]. Diesel prices in Thailand had a relationship with the value of Thai gem and jewelry exports to Switzerland. Diesel prices in Thailand are considered a production cost. When the diesel prices increased, the cost of production increased, and the price of diesel would drop rapidly affecting the Thai economy in both positive and

negative ways [31, 32]. For the positive side, entrepreneurs would have to lower production costs, especially the cost of transportation, so consumers could have increased purchasing power. As for the negative side, the price of diesel in Thailand would have an impact on the export of Thai goods and services, whether it was the prices of various commodities and raw materials rising. The problem of inflation and the rising cost of living would also result in a decrease in the purchasing power of the people. Therefore, when the price of diesel changed, this would cause the export value of gems and jewelry to decrease along with the production volume [33, 34].

8. CONCLUSION

The gem and jewelry industry are important to Thailand economic development. This industry has the third highest export value of Thailand's total export value. Gems and jewelry are important export products that generate the main income for the country. In addition, the problems and obstacles include fluctuating raw material prices, shortage of raw materials, and Thai entrepreneurs still lack opportunities to develop their products.

There are still several restrictions on this research procedure. Firstly, the research participants for this research were limited to a single industry type that is significantly influenced by economic factors. Nonetheless, the application of export value is an important matter that necessitates the cooperation of all industry types. Businesses' paths to economic development are influenced by the wide variations in the industrial environments in which they operate across various industries [35]. Future research can therefore incorporate other industry types to conduct more comprehensive studies.

Secondly, the data used in this research was collected during the COVID-19 outbreak (2020–2023), which could have inaccurate analytical results because of external factors including shifting consumer behavior, business operations, and economic factors.

Thirdly, this research solely examined only economic factors. When combined with other factor such as customer behavior, export price index, labor skills, and Industrial Production Index, this could make a distinct analysis point of view. Furthermore, predictive models like machine learning, data mining, and mathematical modelling are used to compare the superior models. As a result, it could make the model more complete.

Finally, this research is predicated on the examination of data from a single nation—the United States. To get more fascinating findings, we need include more customer groups, such as those from Thailand's main export values such as England, France, Belgium, or Japan.

Furthermore, this research recommends that the government implement policies that encourage the export of Thai gem and jewelry. These policies could include regulating to control the production and logistics costs, such as the price of gold, which is a material used in the gem and jewelry industry, or diesel price, which is primarily a transportation system expense. The government and gem and jewelry manufacturers can plan production and marketing to meet demand more effectively and efficiently by using the research's findings, which show the amount of or export value in the market.

ACKNOWLEDGMENT

This research was funded by the Mahasarakham University, Thailand.

REFERENCES

- [1] Bangkokbiznews. (2024). Gem and jewelry exports in September 2023 recover. Available: <https://www.bangkokbiznews.com/business/economic/1097936>.
- [2] Rajbhandari, S., Winyuchakrit, P., Pradhan, B.B., Chaichaloempreecha, A., Pita, P., Limmeechokchai, B. (2024). Thailand's net-zero emissions by 2050: Analysis of economy-wide impacts. *Sustainability Science*, 19(1): 189-202. <https://doi.org/10.1007/s11625-023-01319-y>
- [3] Chemsripong, S. (2024). Influence of business model and marketing environment of Thai gems and jewellery during COVID-19 pandemic: Opportunities and challenges. *International Journal of Learning and Change*, 16(2-3): 262-282. <https://doi.org/10.1504/IJLC.2024.137499>
- [4] Chutijirawong, N. (2023). 2023 Thailand's economic outlook. <https://www2.deloitte.com/th/en/pages/about-deloitte/articles/2023-thailand-economic-outlook-en.html.html>.
- [5] Bureau, B.M. (2023). Gem, jewellery exports up 3% in FY23 despite dull demand. <https://www.thehindubusinessline.com/economy/gem-jewellery-exports-up-3-in-fy23-despite-dull-demand/article66751269.ece>.
- [6] Jevdjevic, M., Listl, S. (2024). Global, regional, and country-level economic impacts of oral conditions in 2019. *Journal of Dental Research*. <https://doi.org/10.1177/00220345241281698>
- [7] DeMarco, A. (2023). First U.S. jewelry show in 2023 presents a look at fashion and business trends. <https://www.forbes.com/sites/anthonydemarco/2023/02/20/first-us-jewelry-show-in-2023-presents-a-look-at-fashion-and-business-trends/>.
- [8] Boonlua, S., Supachaiwat, J., Thongchua, K., Mohamad, B. (2023). Linking supply chain resilience strategies for surviving major disruptions. *International Journal of Construction Supply Chain Management*, 13(1): 154-172. <https://doi.org/10.14424/ijscsm2023130109>
- [9] Cole, G. (2024). Thriving in the future labor market. <https://www.deloitte.com/global/en/services/consulting/perspectives/thriving-in-the-future-labor-market.html>.
- [10] US News. (2023). Summary of the US gem and jewelry market situation. <https://www.ditp.go.th/post/149736>.
- [11] Ratakam, P., Petison, P. (2023). From means to end: Understanding the millennial mind when buying luxury jewelry brands. *Journal of Global Fashion Marketing*, 14(1): 35-47. <https://doi.org/10.1080/20932685.2022.2085606>
- [12] Zhang, Y., Xie, M., Wang, Y. (2024). Metal trade and contraband: Archaeological discoveries and insights from the Nanhai No. 1 merchant shipwreck. *Journal of Maritime Archaeology*, 19(2): 265-289. <https://doi.org/10.1007/s11457-024-09400-y>
- [13] Ball, L.M., Leigh, D., Mishra, P. (2022). Understanding U.S. inflation during the COVID era. <https://www.imf.org/en/Publications/WP/Issues/2022/10/28/Understanding-U-S-525200>.
- [14] CWC. (2023). Jewelry market statistics. <https://classywomencollection.com/blogs/fashion-guide/jewelry-market>.
- [15] Uzunoglu, C. (2024). Top 5 online jewelry & watches stores in the United States: Market growth, development. <https://ecommercedb.com/insights/top-5-online-jewelry-watches-stores-in-the-u-s-market-development-top-online-stores/4610>.
- [16] Dananjoyo, R., Wibowo, A.A. (2024). The role of customer relationship management to strengthen customer satisfaction using product innovation and customer value as intervening variable. *E3S Web of Conferences*, 571: 02007. <https://doi.org/10.1051/e3sconf/202457102007>
- [17] Ali, H.M., Mahdi, L.A. (2023). Exergy analysis of chest freezer working with R-134a and R-600a at steady state conditions. *International Journal of Energy Production and Management*, 8(2): 63-70. <https://doi.org/10.18280/ijepm.080202>
- [18] Phittayanon, C., Rungreunganun, V. (2019). Analyzing factors influencing industrial competitiveness of Thai silver jewelry industry using analytic hierarchy process. *International Journal of Mechanical Engineering and Technology*, 10(3): 1301-1312.
- [19] Phongphornworachai, R. (2021). Factors of investment decision making affecting the market share expansion of gem and jewelry: The case of Belgium. *Chulalongkorn University Theses and Dissertations (Chula ETD)*. <https://doi.org/10.58837/CHULA.IS.2021.58>
- [20] Palma, E.P., Gomes, C.M., Kruglianskas, I., Kneipp, J.M., da Rosa, L.A.B., Frizzo, K. (2018). Relationship between sustainable strategies and export performance: An analysis of companies in the Brazilian gems and jewelry industry. *Environmental Quality Management*, 27(4): 97-106. <https://doi.org/10.1002/tqem.21557>
- [21] Rastogi, R., Mwaitete, C.P. (2018). Gold export analysis and influence to the economy of Tanzania: Multiple regression analysis. *Journal of Economics and Sustainable Development*, 9(8): 55-63.
- [22] Promkaew, N., Umpunjun, P., Chuenboonngarm, N., Viboonjun, U. (2024). Development of a molecular maker for sex identification in Thai commercial date palm (*Phoenix dactylifera* L.). *Plant Biotechnology*, 41(1): 45-51. <http://doi.org/10.5511/plantbiotechnology.23.1214b>
- [23] Dananjoyo, R., Udin, U., Idris, A. (2024). Mediating roles of customer engagement and satisfaction in the connection between e-retail customer experience and loyalty. *International Journal of Sustainable Development and Planning*, 19(2): 751-759. <https://doi.org/10.18280/ijstdp.190232>
- [24] Bland, J.M., Altman, D.G. (1996). Statistics notes: Transforming data. *BMJ*, 312(7033): 770. <https://doi.org/10.1136/bmj.312.7033.770>
- [25] Devore, J.L., Peck, R. (1995). *Statistics: The Exploration and Analysis of Data*, 4th ed. New York: Duxbury Press.
- [26] White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica: Journal of the Econometric Society*, 48(4): 817-838.
- [27] Durbin, J., Watson, G.S. (1951). Testing for serial correlation in least squares regression. II. *Biometrika*, 38(1-2): 159-178. <https://doi.org/10.1093/biomet/38.1->

- [28] Lieberman, M.G., Morris, J.D. (2014). The precise effect of multicollinearity on classification prediction. *Multiple Linear Regression Viewpoints*, 40(1): 5-10.
- [29] Hair Jr, J.F., Black, W.C., Babin, B.J., Anderson, R.E. (2009). *Multivariate Data Analysis* (7th Edition). Pearson Education.
- [30] Ratakam, P., Petison, P. (2023). From means to end: Understanding the millennial mind when buying luxury jewelry brands. *Journal of Global Fashion Marketing*, 14(1): 35-47. <https://doi.org/10.1080/20932685.2022.2085606>
- [31] Wang, G., Sharma, P., Jain, V., Shukla, A., Shabbir, M.S., Tabash, M.I., Chawla, C. (2022). The relationship among oil prices volatility, inflation rate, and sustainable economic growth: Evidence from top oil importer and exporter countries. *Resources Policy*, 77: 102674. <https://doi.org/10.1016/j.resourpol.2022.102674>
- [32] Boonlua, S. (2011). A comparative analysis of the US and Japan FDI in Thailand. *Journal of Academy of Business and Economics*, 11(3): 71-83.
- [33] Krungthai Asset Management. (2022). KTAM daily update. https://classic.wealthmagik.com/Upload/Content/AnalysisFile/KTAMRD_Daily_221011.pdf.
- [34] Scarrà, D., Piccaluga, A. (2022). The impact of technology transfer and knowledge spillover from Big Science: A literature review. *Technovation*, 116: 102165. <https://doi.org/10.1016/j.technovation.2020.102165>
- [35] Bugarčić, F.Ž., Stanišić, N., Marinković, V. (2024), Assessing the effects of logistics performance on export and competitiveness using SEM methodology: Evidence from firm-level data. *The International Journal of Logistics Management*, 35(6): 1847-1866. <https://doi.org/10.1108/IJLM-07-2023-0289>