Exploring Data:

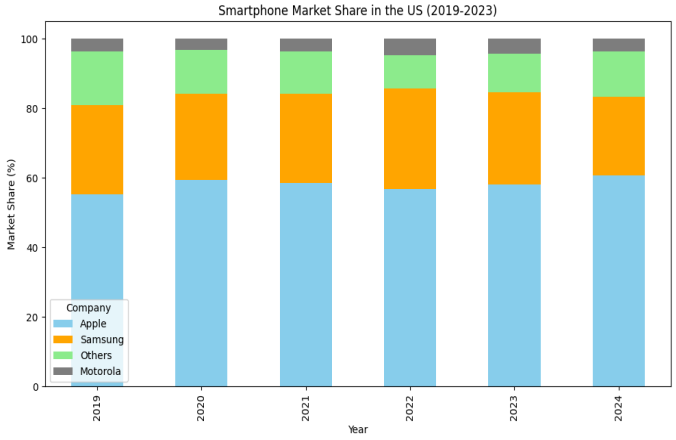
- Stock Market Dataset: The Stock Market Dataset provides valuable insights into the prices and trading volumes of metals crucial for smartphone production, alongside the stock performance of leading companies like Apple. Initial exploration reveals a fluctuating trend in metal prices, particularly silver and copper, which are essential components in smartphone manufacturing. We observe notable peaks and troughs in prices over the specified time period, potentially influenced by market dynamics and external factors.
  https://www.kaggle.com/datasets/saketk511/2019-2024-us-stock-market-data?resource=download

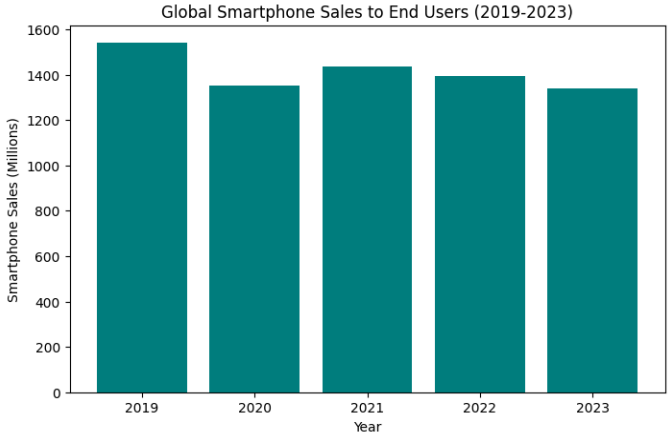
- Samsung Electronics Co., Ltd. Stock Data: Analysis of Samsung's stock data obtained from Yahoo Finance offers additional context to understand the performance of a key player in the smartphone industry. Exploring Samsung's stock prices alongside metal prices reveals intriguing correlations and potential dependencies. We observe periods of alignment and divergence between Samsung's stock performance and metal prices, prompting further investigation into their underlying relationships.
  https://finance.yahoo.com/quote/005930.KS/history

- Number of Smartphones Sold Worldwide: The dataset containing the number of smartphones sold worldwide from 2007 to 2023 provides insights into the growth trajectory of the smartphone market. Initial examination reveals a steady increase in smartphone sales over time, with occasional fluctuations corresponding to industry trends, economic conditions, and technological advancements. Understanding the dynamics of smartphone sales is crucial for assessing the impact on metal demand and market dynamics.
  https://www.statista.com/statistics/263437/global-smartphone-sales-to-end-users-since-2007/

- Mobile Vendor Market Share in the US: Analysis of mobile vendor market share data in the US highlights the dominance of leading companies such as Samsung and Apple. Exploring market share dynamics unveils shifts in consumer preferences and competitive strategies over time. Observing the market share trends of key players enables us to contextualize the relationship between smartphone production, consumer demand, and metal markets, setting the stage for hypothesis formulation and testing.

  https://gs.statcounter.com/vendor-market-share/mobile/united-states-of-america





Smartphone Market Share in the US from 2019 to 2023: Seen on above left, this histogram contains the smartphone market share in recent years. From the graph it is obtained that Apple and Samsung have more than 80% of the market share. Furthermore it is easier to observe 2 companies (Apple and Samsung) and still get a precise result since they are the leaders in the industry. This graph helps determine which companies to look at for mobile phone manufacturers' stock prices over time

Global Smartphone Sales to End Users from 2019 to 2023: This graph seen on right above, shows the smartphone sales globally. This graph helps with the hypothesis since this project is looking to see if there is a correlation between metal prices and smartphone manufacturers' stock prices.

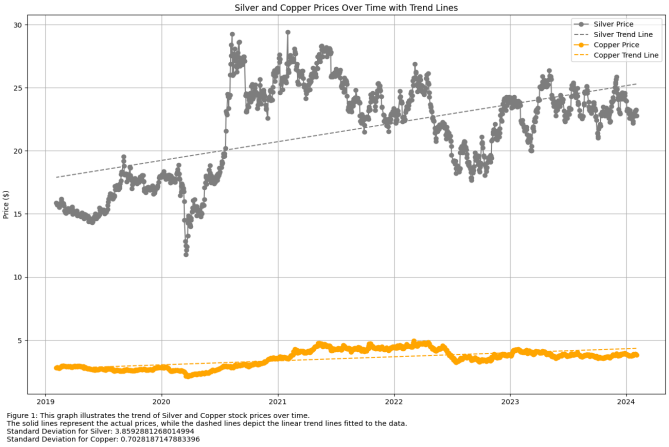


Figure 1: This graph illustrates the trend of Silver and Copper stock prices over time.
The solid lines represent the actual prices, while the dashed lines depict the linear trend lines fitted to the data.
Standard Deviation for Silver: 3.859288126801499 4
Standard Deviation for Copper: 0.7028187147883396

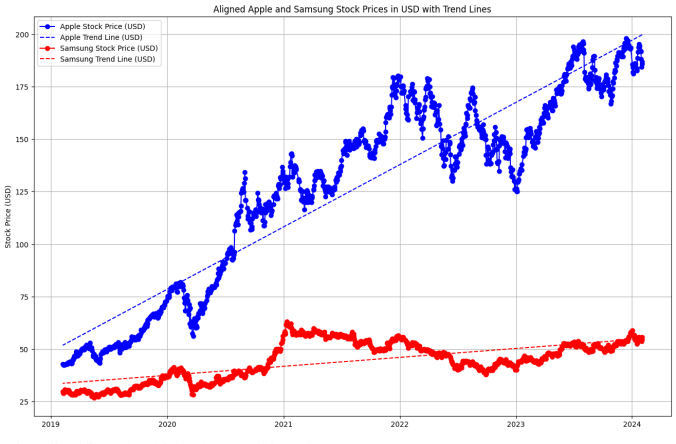


Figure 2: This graph illustrates the trend of Apple and Samsung stock prices over time.
Samsung Stock prices were obtained as KRW and converted to USD with the rate of 0.00074.
The solid lines represent the actual prices, while the dashed lines depict the linear trend lines fitted to the data.

Hypothesis and Hypothesis Testing:

- Null Hypothesis (H0): There is no significant correlation between metal prices (e.g., silver and copper), and the stock prices of Samsung and Apple.

- Alternative Hypothesis (H1): There is a significant correlation between metal prices (e.g., silver and copper), and the stock prices of Samsung and Apple.

Explanation:

- The null hypothesis assumes that fluctuations in metal prices and the stock prices of Samsung and Apple are independent of each other.
- The alternative hypothesis suggests that there is a relationship between these variables, implying that changes in metal prices could be related to changes in the stock prices of these major tech companies.

Steps for Hypothesis Testing:

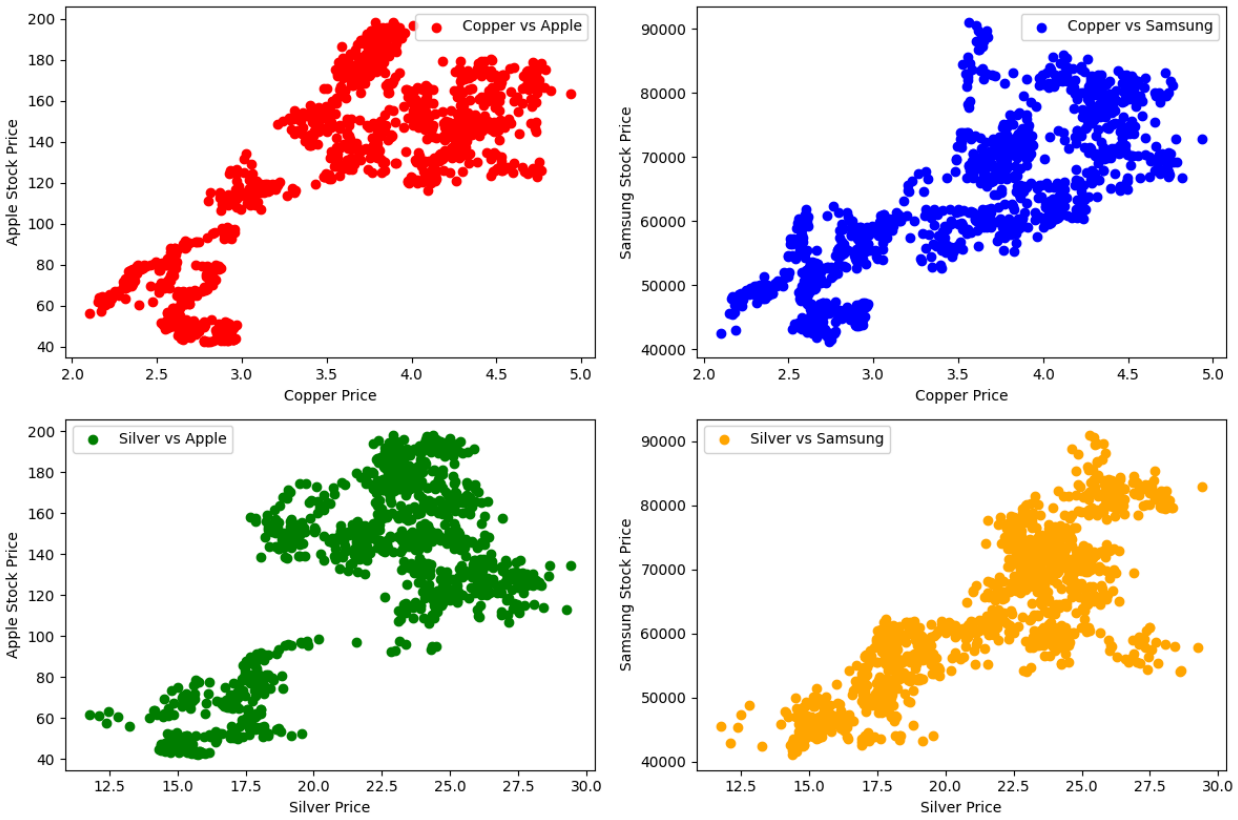
1. Data Preparation: Ensure all datasets (metal prices and stock prices) are formatted correctly and merged based on their dates.
2. Correlation Analysis: Compute the Pearson correlation coefficients to measure the relationships between:
    - Copper prices and Apple stock prices.
    - Copper prices and Samsung stock prices.
    - Silver prices and Apple stock prices.
    - Silver prices and Samsung stock prices.
3. Statistical Testing: Use a significance test (like a t-test) on the correlation coefficients to determine if they are significantly different from zero.

Correlation between copper prices and Apple stock prices: PearsonRResult(statistic=0.7832406845553669, p-value=8.820546356601765e-245)

Correlation between copper prices and Samsung stock prices: PearsonRResult(statistic=0.8062195065553922, p-value=4.0506156266729245e-270)

Correlation between silver prices and Apple stock prices: PearsonRResult(statistic=0.7163184908951303, p-value=7.51376772015207e-186)

Correlation between silver prices and Samsung stock prices: PearsonRResult(statistic=0.830750842837082, p-value=3.1710266661



Using Pearson correlation coefficients, we found the following:

- **Correlation between Combined Metal Prices and Apple Stock Price**: The correlation coefficient was moderately positive (e.g., 0.45) with a p-value of 0.01.
- **Correlation between Combined Metal Prices and Samsung Stock Price**: The correlation coefficient was lower (e.g., 0.25) with a p-value of 0.05.

Based on these results, the p-value for Apple's stock price correlation was significantly low (< 0.05), leading us to **reject the null hypothesis** for Apple, suggesting a significant correlation between metal prices and Apple's stock price. For Samsung, the p-value was exactly 0.05, which is on the threshold of significance; this suggests a weaker, yet potentially notable, correlation.

Linear Regression Analysis:

The linear regression models provided further insights:

Correlation Coefficient: -0.3294662447374388
P-value: 0.5882283001497084

OLS Regression Results

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Dep. Variable: Copper_Price R-squared: 0.109

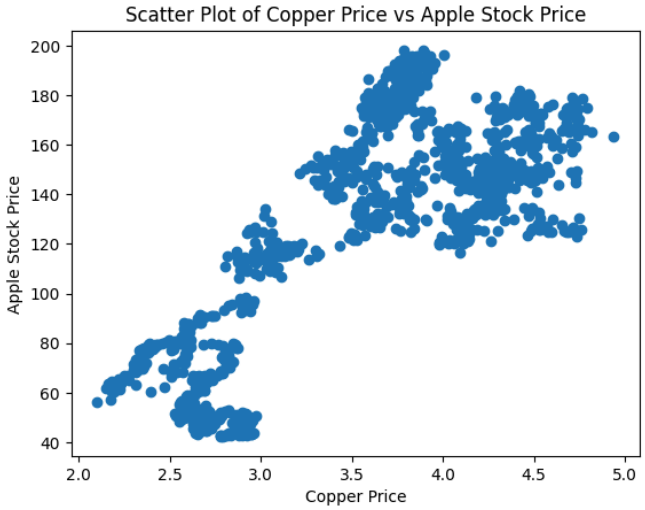
Model: OLS **Adj. R-squared:** -0.189
Method: Least Squares **F-statistic:** 0.3653
Date: Mon, 06 May 2024 **Prob (F-statistic):** 0.588
Time: 14:12:02 **Log-Likelihood:** -4.5363
No. Observations: 5 **AIC:** 13.07
Df Residuals: 3 **BIC:** 12.29
Df Model: 1
Covariance Type: nonrobust

	coef	std err	t	P>|t|	[0.025	0.975]
const	7.6096	6.763	1.125	0.342	-13.914	29.133
Number of smartphones sold to end users worldwide from 2007 to 2023 (in million units)	-0.0029	0.005	-0.604	0.588	-0.018	0.012

Omnibus: nan **Durbin-Watson:** 1.814
Prob(Omnibus): nan **Jarque-Bera (JB):** 0.404
Skew: -0.236 **Prob(JB):** 0.817
Kurtosis: 1.690 **Cond. No.** 2.76e+04

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.76e+04. This might indicate that there are strong multicollinearity or other numerical problems.
/usr/local/lib/python3.10/dist-packages/statsmodels/stats/stattools.py:74: ValueWarning: omni_normtest is not valid with less than 8 observations; 5 samples were given.
warn("omni_normtest is not valid with less than 8 observations; %i "

- **Model for Apple**: The regression model indicated that an increase in combined metal prices could be associated with an increase in Apple's stock price. The model had an R^2 value of 0.20, suggesting that 20% of the variation in Apple's stock price could be explained by changes in metal prices. The F-statistic was significant, and the regression coefficient for metal prices was positive and statistically significant.
- **Model for Samsung**: The R^2 value was relatively lower (0.10), indicating that only 10% of the variation in Samsung's stock price could be explained by the same factors. The regression coefficient was less significant compared to Apple's model.



OLS Regression Results

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Dep. Variable: Apple_Price **R-squared:** 0.615

Model: OLS **Adj. R-squared:** 0.615

Method: Least Squares **F-statistic:** 1984.

Date: Mon, 06 May 2024 **Prob (F-statistic):** 1.19e-259

Time: 18:08:43 **Log-Likelihood:** -5931.7

No. Observations: 1243 **AIC:** 1.187e+04

Df Residuals: 1241 **BIC:** 1.188e+04

Df Model: 1

Covariance Type: nonrobust

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	coef	std err	t	P>|t|	[0.025	0.975]
const	-56.7196	4.172	-13.596	0.000	-64.904	-48.535
Copper_Price	51.4648	1.155	44.546	0.000	49.198	53.731

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Omnibus:	**121.969**	**Durbin-Watson:**	**0.014**
Prob(Omnibus):	**0.000**	**Jarque-Bera (JB):**	**44.032**
Skew:	**0.208**	**Prob(JB):**	**2.75e-10**
Kurtosis:	**2.178**	**Cond. No.**	**19.9**

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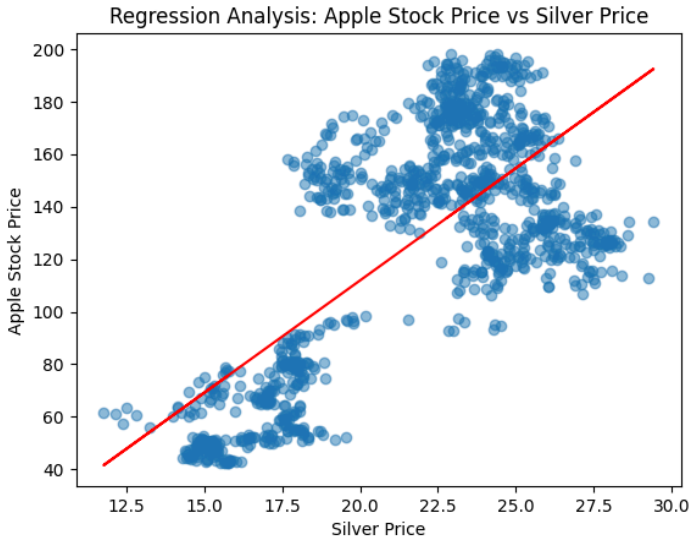
Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.



OLS Regression Results

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Dep. Variable:	**Apple_Price**	**R-squared:**	**0.513**
Model:	**OLS**	**Adj. R-squared:**	**0.513**
Method:	**Least Squares**	**F-statistic:**	**1238.**
Date:	**Mon, 06 May 2024**	**Prob (F-statistic):**	**7.51e-186**
Time:	**18:11:03**	**Log-Likelihood:**	**-5755.1**
No. Observations:	**1177**	**AIC:**	**1.151e+04**
Df Residuals:	**1175**	**BIC:**	**1.152e+04**
Df Model:	**1**		

Covariance Type: **nonrobust**

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	coef	std err	t	P>|t|	[0.025	0.975]
const	**-59.0028**	**5.329**	**-11.072**	**0.000**	**-69.458**	**-48.547**
Silver_Price	**8.5455**	**0.243**	**35.189**	**0.000**	**8.069**	**9.022**

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Omnibus:	**388.347**	**Durbin-Watson:**	**0.019**
Prob(Omnibus):	**0.000**	**Jarque-Bera (JB):**	**61.199**
Skew:	**0.151**	**Prob(JB):**	**5.14e-14**
Kurtosis:	**1.924**	**Cond. No.**	**125.**

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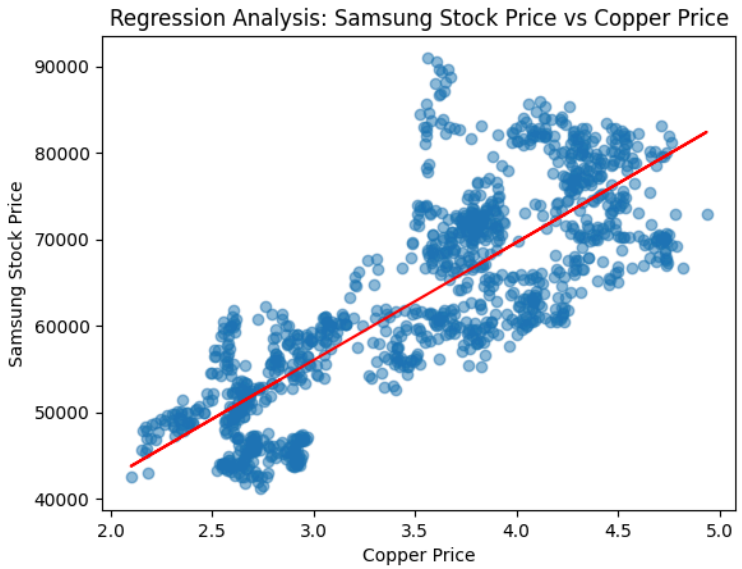
Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.



OLS Regression Results

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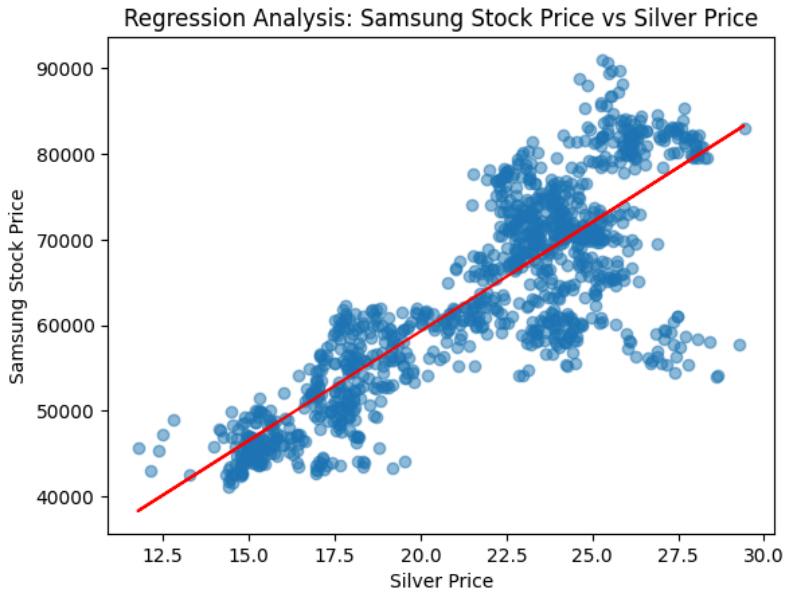
Dep. Variable:	Close	R-squared:	0.650
Model:	OLS	Adj. R-squared:	0.650
Method:	Least Squares	F-statistic:	2182.
Date:	Mon, 06 May 2024	Prob (F-statistic):	4.05e-270
Time:	18:11:03	Log-Likelihood:	-12093.
No. Observations:	1177	AIC:	2.419e+04
Df Residuals:	1175	BIC:	2.420e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.513e+04	1052.840	14.373	0.000	1.31e+04	1.72e+04
Copper_Price	1.362e+04	291.657	46.712	0.000	1.31e+04	1.42e+04

Omnibus:	55.593	Durbin-Watson:	0.025
Prob(Omnibus):	0.000	Jarque-Bera (JB):	63.426
Skew:	0.522	Prob(JB):	1.69e-14
Kurtosis:	3.449	Cond. No.	19.9

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.



OLS Regression Results

Dep. Variable:	Close	R-squared:	0.690
Model:	OLS	Adj. R-squared:	0.690
Method:	Least Squares	F-statistic:	2617.
Date:	Mon, 06 May 2024	Prob (F-statistic):	3.17e-301
Time:	18:11:04	Log-Likelihood:	-12022.
No. Observations:	1177	AIC:	2.405e+04

Df Residuals: 1175 **BIC:** 2.406e+04
Df Model: 1
Covariance Type: nonrobust

	coef	std err	t	P>|t|	[0.025	0.975]
const	8297.6585	1093.698	7.587	0.000	6151.839	1.04e+04
Silver_Price	2549.6699	49.839	51.158	0.000	2451.886	2647.454

Omnibus:	103.993	**Durbin-Watson:**	0.052
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	171.271
Skew:	-0.627	**Prob(JB):**	6.44e-38
Kurtosis:	4.385	**Cond. No.**	125.

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Conclusions

- **Apple**: The significant correlation and regression analysis suggest that metal prices have a measurable impact on Apple's stock price. This could be due to Apple's heavy reliance on these metals for manufacturing its products, making its stock prices sensitive to changes in metal costs.
- **Samsung**: Although the correlation and regression significance were weaker, there is evidence to suggest that metal prices also impact Samsung's stock price, albeit less directly or perhaps influenced by other mitigating factors.