THE RELATIONSHIP BETWEEN THE PRICE OF GOLD AND THE STOCK MARKET: A TECHNICAL ANALYSIS

Research Methods Report

FEBRUARY 28, 2023

Bassem Boustany
Hasan Ibrahim El Husseini
Cyril Smaira
Arnau Garcia Cequel

Professor: Jan Schnitzler

I. Introduction

The usage of gold can be traced back to ancient civilizations such as the Egyptians, Greeks, and Romans, who used it for jewelry, decorations, and coins. Add to that it has been used as a form of currency and a valuable commodity for thousands of years.

Also, in the following years that included Middle Ages and the Renaissance, gold continued to be utilized as a currency. Commonly, gold coins were circulated throughout Europe and the Middle East.

During the 19th century, "The Gold Standard" was established. The underlying idea of the standard is that the value of currencies are now linked to gold.
Meaning that under this standard, countries could exchange their paper currency for gold at a fixed rate in order to help stabilizing the value of currencies.

The gold standard remained effective until the mid-20th century where it was gradually abandoned in favor of fiat currency. A fiat currency is not backed by a physical commodity like gold.

Even though currency values are no longer linked to gold, it still has a very crucial role in financial markets – safe haven -

This paper aims to test the historical relationship between gold prices with:

1. S&P 500
2. Dow Jones Industrial Average
3. Mining Companies (KGC, NEM, GOLD)

Our objective from this proposed research is to better understand how gold and these variables interact during different economic situations. Also, it aims at revealing the relationship between gold prices and mining companies.

Can gold be an alternative investment during economic downturns?

II. Literature Review

Gold

Gold is perceived as a safe haven asset, meaning that investors often turn to it during times of economic uncertainty, volatility, crises. The underlying reason is that gold tends to hold its value, even when other assets like stocks and bonds are experiencing significant fluctuations.

Gold is often used as a hedge instrument against market volatility and economic uncertainty. It tends to have a low correlation with other asset classes. This means that adding gold to a portfolio can help diversify risk and potentially improve overall returns.

Gold is a tangible asset: it is a physical asset that can be held. This gives it an intrinsic value and reduces the risk of default or counterparty risk which makes it more secure compared to financial assets that are dependent on the performance of a third party, such as stocks or bonds.

As a result, gold is often used as a protection instrument against inflation and currency devaluation.

In addition to being used by individual investors as mentioned above, gold is also traded on financial markets. It can be traded through various financial instruments, such as exchange-traded funds (ETFs), futures contracts, and options.

The price of gold is determined by supply and demand factors, including economic conditions, global events, and mining output

Overall, gold has a rich history as a valuable commodity and currency, and its role in financial markets continues to be significant as a safe haven asset and a trading instrument.

S&P500

The S&P 500 is a stock market index that measures the performance of 500 large-cap U.S. companies listed on the New York Stock Exchange (NYSE) or Nasdaq. The index is often used as a benchmark by investors to compare their investment returns.
The S&P 500 is calculated and maintained by Standard & Poor's, a financial services company that provides research, analysis, and ratings on various financial instruments.

The companies listed on S&P 500 come from a wide range of industries, including technology, healthcare, financials, consumer goods, and energy. The index is regularly updated to reflect changes in the underlying companies, such as mergers and acquisitions, or bankruptcies.

Investors, economists and policymakers closely monitor the performance of the S&P 500 because it is an indicator of the overall health of the U.S. economy.
The value of the S&P 500 Index is computed by a free float market capitalization-weighted methodology.

Dow Jones Industrial Average

Known as (DJIA) is a stock market index that represents 30 large publicly traded companies in the United States. It is one of the oldest and most widely followed stock market indexes in the world. The editors of The Wall Street Journal select the 30 companies that make up the DJIA. The companies are chosen based on the following criteria: reputation, size, and industry representation, with the aim of providing a broad representation of the U.S. economy.

Similar to S&P 500, it is closely monitored by investors, analysts, and economists.
The Dow is a price-weighted index, which means that each stock in the index is weighted based on its price per share rather than its market capitalization.

Kinross Gold Corporation (KGC)

Founded in 1993, Kinross Gold Corporation (Ticker KGC) is a Canadian-based gold mining company that operates in different regions around the world, including North America, South America, Africa, and Russia.
As of September 2021, KGC had nine operating mines, four development projects, and numerous exploration projects.
Its current production comes from mines located in:

- North America (Fort Knox, Round Mountain, and Bald Mountain)
- Russia (Kupol and Dvoinoye)
- West Africa (Chirano and Tasiast)
- South America (Paracatu)

KGC's main product is gold, but the company also produces small amounts of silver. In 2020, the company produced approximately 2.4 million gold equivalent ounces.

From a financial point of view KGC reported revenues of approx. US$4.9 billion in 2020 and had a market capitalization of approximately US$11.7 billion as of September 2021. The company employs approximately 9,000 people worldwide.
In 2020, Kinross Gold Corporation produced approximately 2.4 million gold equivalent ounces.

Newmont Corporation (NEM)

Newmont Corporation is one of the world's largest gold mining companies. It was founded in 1921 and has its headquarters in Denver, Colorado, USA. The company has operations in North America, South America, Australia, and Africa.

Newmont's primary focus is gold, but it also produces copper, silver, lead, and zinc. The company's major mining operations are located in the Carlin, Phoenix, and Long Canyon mines in Nevada, USA; the Yanacocha mine in Peru; and the Boddington mine in Australia.
NEM has a long history of growth through M&A, for example the acquisition of Goldcorp in 2019, which made Newmont the world's largest gold producer at the time. The company is also known for its strong operational and financial performance, and its commitment to sustainability and responsible mining practices.

In terms of financials, Newmont Corporation reported revenues of approximately US$11.5 billion in 2020 and had a market capitalization of approximately US$51.4 billion as of September 2021. The company employs approximately 16,000 people globally.
In 2020, Newmont Corporation produced approximately 5.9 million ounces of gold.

Barrick Gold

Barrick Gold Corporation is a Canadian mining company that specializes in the exploration, development, and production of gold and copper. The company was founded in 1983 by Peter Munk and has since grown to become one of the largest gold mining companies in the world.

Barrick Gold operates mines and projects in several countries, including the United States, Canada, Australia, Papua New Guinea, Chile, Argentina, and Tanzania. The company's primary focus is on gold mining, but it also produces significant amounts of copper and other minerals.

Barrick Gold is publicly traded on several stock exchanges, including the New York Stock Exchange and the Toronto Stock Exchange, under the ticker symbol "GOLD". The company is known for its high-quality mining operations, commitment to responsible mining practices, and strong relationships with local communities and governments.

Financially speaking, GOLD reported revenues of approximately USD 11.985 billion in 2021 and had a market cap of approximately USD 30.27 in 2022. The company has approximately 18,420 employees globally. In 2021, Barrick Gold produced approximately 4.4 million ounces of gold, which is a significant amount.

III. Methodology

The methodology of this study will be discussed in this section. This will go over the tools used to extract the relevant data, its source and the quantitative techniques used in order to analyze the data. The use of appropriate techniques allows for an adequate examination of the historical correlation between gold prices and the stock market.

Data extraction

The financial information used to establish an adequate data set for this study was extracted from the Yahoo Finance API, through the usage of the *yfinance* module available for Python. The data extracted encompasses the historical closing prices of gold (^XAU), the S&P500 (^GSPC), Dow Jones Industrial Average (^DJI) and the NYSE stocks of the following mining companies: Barrick Gold (GOLD), Newmont Corporation (NEM) and Kinross Gold Corporation (KGC). The financial data covers the period between 2013 and 2023, which grants us a wide window to perform technical analyses. In order to perform the latter adequately however, the daily percentage changes had to be computed and stored in a spreadsheet (.csv). The reason it is stored in such a file is to ensure that the program runs smoothly every time without the interruption of any anti-scraping procedures put in place by Yahoo Finance's API.

Analysis techniques

To establish the relationship between the dependent variable and independent variables, historical price charts are generated using Python's *MatPlotLib* module, with different intervals (daily, weekly, monthly and yearly) to evaluate any possible relationship on different levels, and with different quantitative natures (individual or cumulative returns) to better fit these different intervals. Moreover, the correlation between the variables is computed through the use of the Pearson Correlation Coefficient available with the *Pandas* Python module, and is plotted for each variable on a heatmap generated by the module *Seaborn.* Finally, an Ordinary Least-Squares model is generated with Python's *Statsmodels* API to extract significance levels (P-

value*s*) for each independent variable and overall goodness-of-fit measure (R-squared) of the regression model.

IV. Results

Correlation between gold prices, S&P500 & DJI:

Depending on the particular time period under consideration, there can be a different correlation between gold and Dow Jones returns on a daily basis. The Dow Jones Industrial Average (DJI) is a stock market index that tracks the performance of 30 significant publicly traded firms in the United States, whereas gold is typically seen as a safe-haven asset that investors like to buy during times of economic instability. Investors may be more inclined to sell equities and purchase gold when the economy and stock market are highly uncertain. This can result in an increase in the price of gold and a decline in the DJI. In contrast, investors may be more inclined to purchase stocks and sell gold when the economy and stock market are experiencing high levels of optimism. This can result in a decline in the price of gold and an increase in the DJI. While the two assets frequently react differently to market developments, the correlation between gold and the DJI is generally low or even negative in the short term (e.g., daily period). Nonetheless, there might be some positive correlation between the two assets over longer time frames (such as monthly or yearly), as both can be impacted by macroeconomic factors like inflation and interest rates. In the following we will dive into each timeframe to understand the reality of the correlation between Gold & DJI. We will also have a look into mining companies returns to see if there is any relationship with Gold & DJI.

The primary focus of our initial investigation is a comparison between the prices of Gold, DJI. This analysis' goal is to spot any trends, patterns, or resemblances throughout distinct time periods. In order to do this, we are using the most reliable and recent data to examine the prices of Gold and the DJI.

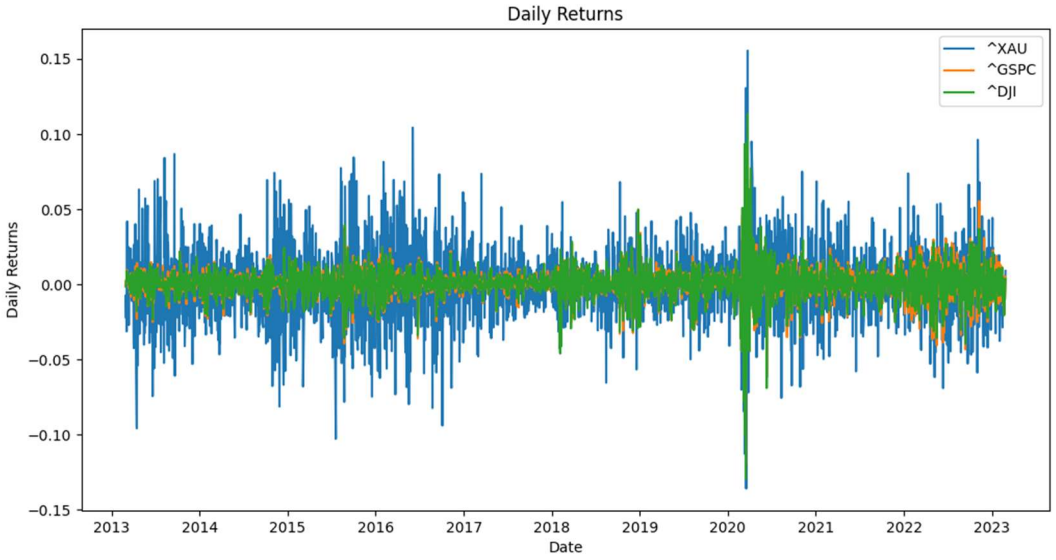


Figure 1. Daily returns of gold prices, S&P500 and DJI.

On the daily timeframe, we can understand the momentum correlation between our three asset classes. What seems to be clear from the daily returns presented above is that there is an important correlation between the volatility of Gold & DJI. We clearly can see that when Gold (blue line) moves aggressively regardless of the direction (positive or negative), the DJI tend to have respective returns. Of course the returns (in percentage) are not the same but we are focusing here on the change in daily volatility. What also catches our attention is the GSPC index returns as they converge on average to the same returns (in percentage) of the DJI, and most of the time in the same direction. This can be explained by the logic of sentiment in the

stock market, especially that we are comparing a global index of 500 US equities to an index of industrial US equities.

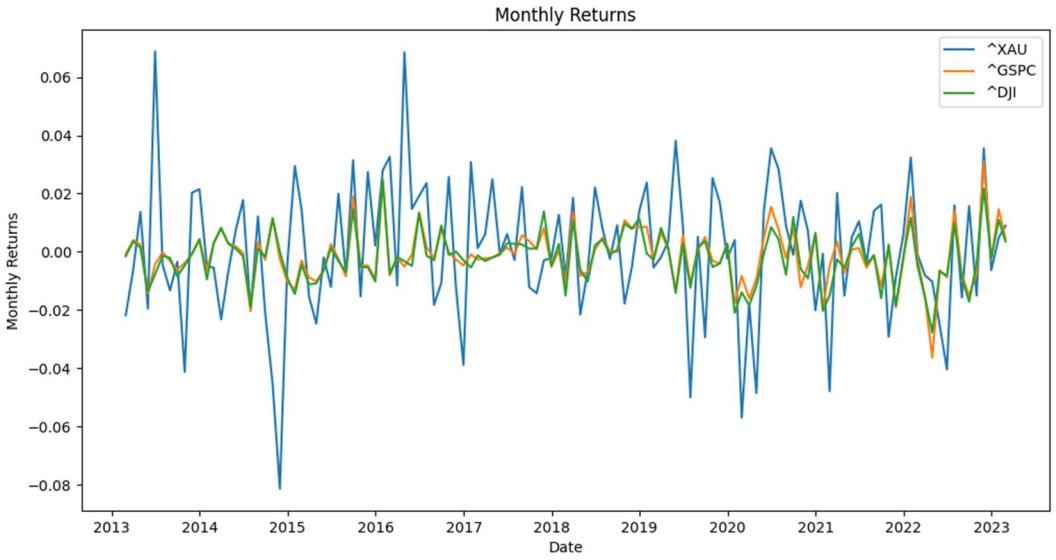


Figure 2. Monthly returns of gold prices, S&P500 and DJI.

Looking now into the monthly returns, we conclude that GSPC and DJI have the same correlation discovered in the daily chart. As for Gold, we cannot come up with a clear conclusion from this chart as we can notice a phase shift in many cases, and an opposite movement in some other cases.

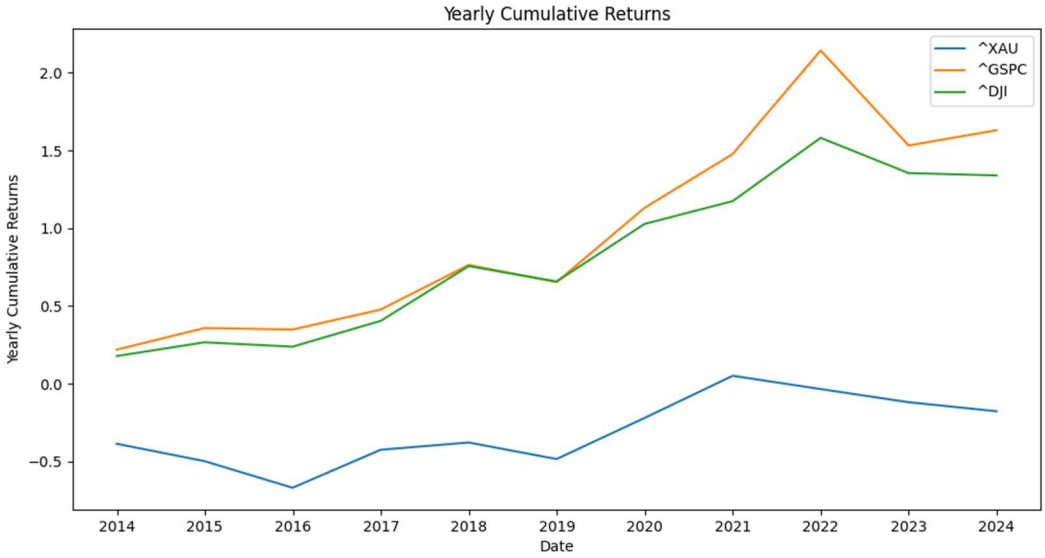


Figure 3. Yearly cumulative returns of gold prices, S&P500 and DJI.

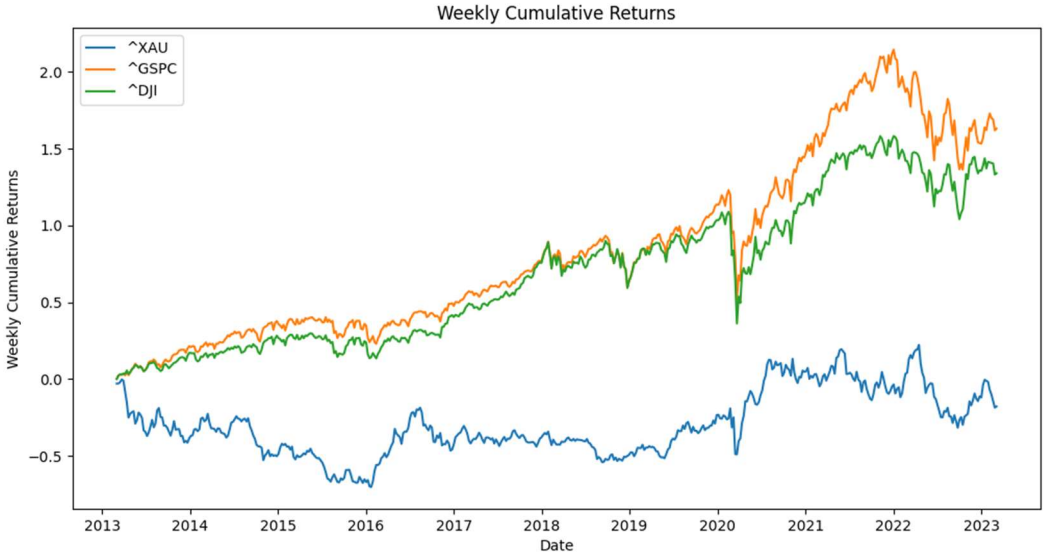


Figure 4. Weekly cumulative returns of gold prices, S&P500 and DJI.

Looking now at the big picture (weekly and yearly cumulative returns), we can notice for the equities indices an uptrend, while Gold cannot be defined in a single direction. What catches the eye is the strong movement of gold's weekly returns while equities indices are having stable returns (2016 - 2017). Overall we can deduce that equities are on the long run on a bullish trend, while gold maintains a stable position, slightly moving upward, and that is because of the reality of inflation, making currencies weakier year by year, thus making the safe-haven metal, XAU, a long-term hedge.

Correlation between Gold, S&P500, DJI & Mining Companies

In this last section of our results analysis, we include in our study a forth asset class, mining companies. We believe that these types of equity by default tend to converge to similar returns and volatilities as gold, so we will put this hypothesis into question on mining companies.

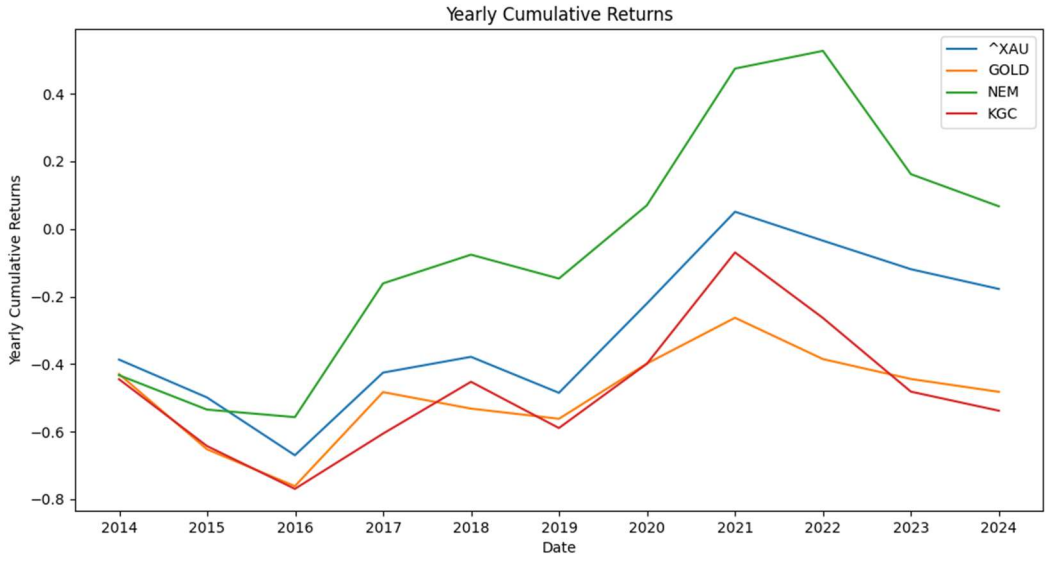


Figure 5. Yearly cumulative returns of gold prices and mining companies.

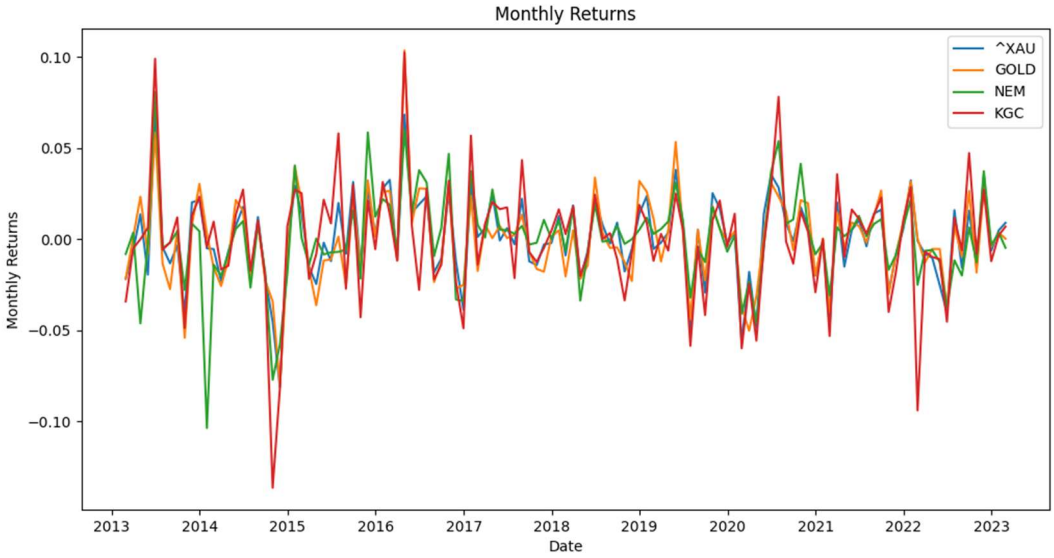


Figure 6. Monthly returns of gold prices and mining companies.

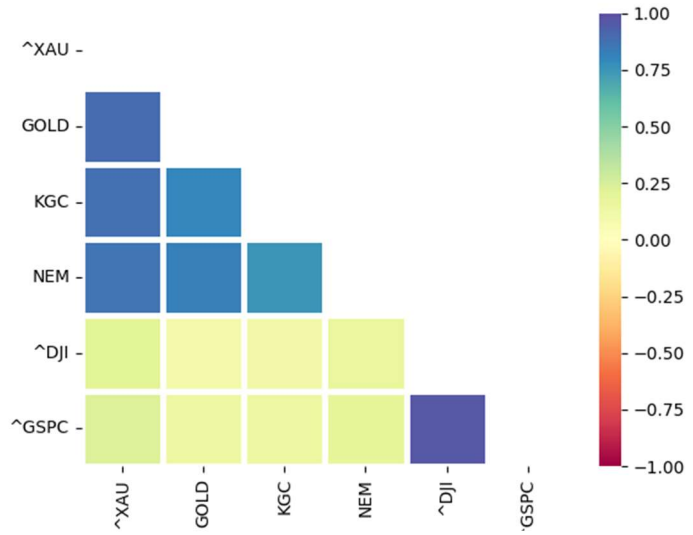
As the charts present monthly returns and yearly cumulative returns, the conclusion meets our initial premise. In fact, not only do mining equities have the same direction of returns as gold prices, but also very often have similar monthly returns and an overall uptrend. We thus deduce a strong positive correlation. The cause of this correlation will be further explored in the next section of this study.

Correlations between gold prices, S&P500, Dow Jones Industrial Average and gold mining companies' stock prices

This study aims to find the relationship between gold, the indices and mining companies' stock prices, because it is possible that the latter might be influenced by fluctuations in the price of gold. For this reason, we have produced a correlation matrix to establish different degrees of correlation, along with a heatmap to better visualize that correlation.

	^XAU	GOLD	KGC	NEM	^DJI	^GSPC
^XAU	1.000000	0.894302	0.877561	0.866600	0.203840	0.230540
GOLD	0.894302	1.000000	0.797604	0.822577	0.107734	0.133389
KGC	0.877561	0.797604	1.000000	0.753459	0.115454	0.141751
NEM	0.866600	0.822577	0.753459	1.000000	0.164199	0.180802
^DJI	0.203840	0.107734	0.115454	0.164199	1.000000	0.963682
^GSPC	0.230540	0.133389	0.141751	0.180802	0.963682	1.000000

Figure 7. Correlation matrix for gold prices (XAU), mining companies stocks (GOLD, KGC, NEM) and market indices (DJI, GSPC)



Tickers:

XAU: Gold price

GOLD: Barrick Gold

KGC: Kinross Gold Corp

NEM: Newmont Corporation

DJI: Dow Jones Industrial Avg.

GSPC: S&P500

Figure 8. Correlation heatmap

Analysis of correlation results

First and foremost, it can be inferred from the matrix that there is a rather weak relationship between the price of gold and the S&P500 and DJI, with correlation coefficients of 0.230 and 0.203, respectively. This could imply that while gold and stock market indices might move in

opposite directions sometimes (as seen on the historical price charts in the previous section), the link between them is generally a more complex one that could is dependent on other factors such as the macroeconomy. As such, there are periods where gold and the stock market move in the same direction, such as during the COVID-19 Pandemic, where they both crashed and rebounded at the same time.

Not surprisingly though, it is very evident that gold mining companies follow gold in the market, as all three companies sampled here have, correlation coefficients of 0.894, 0.877 and 0.866, which indicates a strong positive correlation with gold prices. This indicates that investors are more likely to invest in these types of companies when the gold is rising, as the latter is the main driving profit factor for this sector of the industry.

Finally, it is interesting to also note the weak relationship between these mining companies and the market indices themselves, as they all show coefficients of correlation between 0.100 and 0.181, once again adding to the argument that the sector related to gold (or other metals) might not follow the traditional market in general.

Ordinary Least-Squares model applied to further study the relationship between the variables

Using the statistical indicators R-Squared and P-values derived from the OLS model, we can further study and validate the relationships between the variables in question in this study.

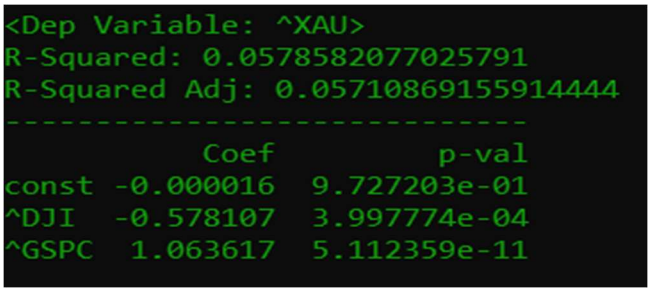


Figure 9. Statistical indicators of the OLS model with gold prices as the dependent variable and market indices as the independent variables.

By running an ordinary least-squares regression with the gold price (XAU) as the dependent variable and the market indices (GSPC) and (DJI) as the independent variables, we can deduce that, while the correlation results are significant ($p < 0.001$), it seems that the independent variables are not explaining much in the variation of gold prices ($R^2 = 0.058$). Interestingly, the coefficient of correlation between gold (XAU) and the S&P500 (GSPC) seems to indicate a positive relationship, although again, due to the bad fit of the model, it should be ignored altogether. This further strengthens the notion, discussed in the previous section, that the gold-to-markets relationship is a complex and dependent on other external economic factors.

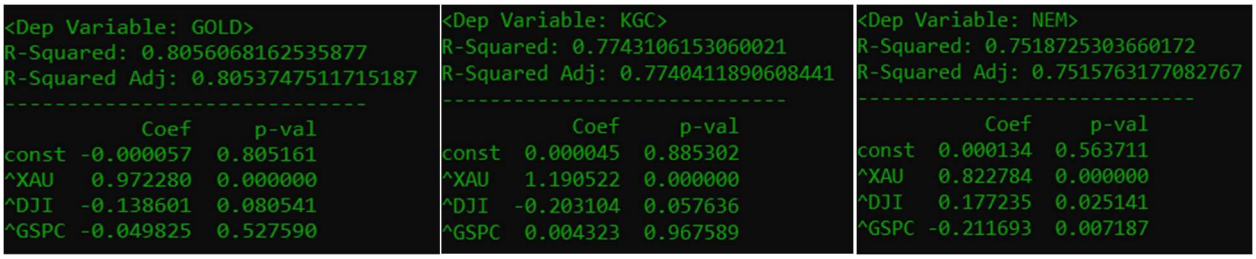


Figure 10 Statistical indicators of the OLS model with mining companies stocks as the dependent variables and gold prices and market indices as the independent variables for each model.

As for the mining companies (GOLD, KGC, NEM), running an OLS regression for each company's stock price as a dependent variable and gold prices along with market indices as the

independent variables produces definite results. The independent variable (XAU) shows strong correlation factors ($r = 0.972$, 1.190 and 0.822) that are statistically significant ($p<0.001$) in each model, with a relatively good fit ($R^2 = 0.805$, 0.774 and 0.752), further pointing to a strong correlation between gold prices and companies operating in the mining industry, and thus pointing to the possibility that investors might also go for these types of stock if they are investing in gold or other similar commodities.

Also, the weak relationship between the mining companies and the S&P500 and DJI indices discussed in the previous section can also be seen here by looking at the correlation coefficients ($r_{GSPC} = -0.049$, 0.004, 0.211 and $r_{DJI} = -0.138$, -0.203, 0.177), although, at least for Barrick Gold (GOLD) and Kinross Gold Corp (KGC), their correlations are not statistically significant ($p>0.05$). This is an indicator that markets such as the ones the S&P500 and DJI represent do no have significant influence over the stock performance of companies that more closely follow a certain commodity's trend line in the market.

V. Conclusion

Key Findings

We can thus draw several deductions from this study regarding the influence of the stock market on the price of gold and the latter's own influence on companies within the mining industry.

The historical charts show that gold prices will in fact sometimes move in the opposite direction of market indices such as the S&P500 and DJI, but not always. This goes without saying

however that gold still holds as a safe-haven asset, as shown by its stable but slow, upwards trend. As for its link to mining companies such as GOLD, KGC and NEM, the strong positive relationship is apparent, as the price of gold is a profit factor for these companies as well as a motivator for the public sentiment when it comes to investing in their stocks.

As for the correlation analyses, it is again deducible that there is no significant relationship between gold and the stock market as a whole, as it is subject to other factors such as the macroeconomy or unique events (e.g. the COVID-19 pandemic). There is, again, however, a strong correlation between the mining companies and the price of gold, further adding proof to the previously said notion regarding public sentiment towards these companies as a result trends in the price of gold. The relationship between the mining companies and the indices however is not so apparent.

Finally, the regression analyses establishes the significance of these findings by evaluating the different statistical indicators (p-values and R-Squared), with the results of the model incorporating gold prices and the indices being lackluster in terms of fitness of independent variables, while the model linking individual mining company stocks to gold prices showed an overall good fit along with statistical significance. The same cannot be said however between mining companies and the indices S&P500 / DJI, further discrediting their relationship within the bounds and parameters of these analyses.

What can be improved upon for future studies

Seeing that the first model had a relatively bad fit, in order to further study the relationship between gold prices and the stock market, it is important that we find more independent variables to include in any future model such as inflation, interest rates, geopolitical event and currency

exchange rates, as that would give us more statistically significant results and help us understand the relation more.

VI. Bibliography

- "S&P500 and Gold", www.goldpriceforecast.com, *https://www.goldpriceforecast.com/explanations/sp-500-and-gold/#:~:text=Negative%20Link%20Between%20S%26P%20500%20and%20Gold&text=The%20standard%20view%20is%20that,gold%20to%20relatively%20risky%20stocks.*
- Yahoo Finance, https://finance.yahoo.com/