Gold Mining Stocks and Their Effects on the Price of Gold

Nicholas Zomparelli | 1000387137

nicholas.zomparelli@mail.utoronto.ca

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1 Introduction

1.1 Background

Historically, gold has been perhaps the most influential metal in the financial world, with monetary systems such as the gold standard controlling the economies of many countries for thousands of years. As a result of this, the price of gold has been closely watched over time and typically indicative of a country's economic status. In August of 2011, the price of gold rose to its highest value ever at $1,900 US dollars (USD) per ounce, before a sharp decrease in the following years and subsequent decrease since. The effects of this rise and fall of gold on the gold mining industry is explored, specifically investigating how stock in the Barrick Gold Corporation (the world's largest gold mining company) was affected.

1.2 Data

Historical datasets of the daily closing prices of gold per ounce (USD) and stock price of the Barrick Gold Coporation (USD) are used in the following analysis. Gold price data was openly available at the Federal Reserve of St. Louis economic data website[1] and historical Barrick Gold stock price was openly available via Yahoo Finance[2]. Each dataset ranges from April 11th, 2011 to April 14th, 2017 and excludes non-trading days such as holidays, weekends, etc.

1.3 Expectations

Naturally, due to the fact that the Barrick Gold Corporation is a gold mining company, we expect to see several trends and similarities across both datasets. To start, it is not surprising to see decreases in both datasets, however what is not known is how influential the datasets are to each other. For example, does the price of gold influence Barrick Gold stock price more or less than Barrick Gold's influence on gold prices? Next, we expect to see a delay or time-shift between the datasets, however the extent of this shift is not known. It is also not known which dataset will be shifted. Lastly, depending on geographical location, gold mining can only/is only allowed during specific times of the year, for instance in North America, gold mining is not possible in the colder winter months. Thus, seasonal changes are expected to be present in the datasets, with relations between the seasonality of each datasets.

2 Methods

In order to analyze and evaluate the raw datasets, various methods and tools are applied to them, each section below outlining specifically the method and results. For reference, the original raw datasets are plotted below in Figures 1 and 2. The drastic decrease in gold price and Barrick Gold stock price is visible

here, with the largest drop in price occurring in the first eight months of 2013. Since then, both prices have not recovered. The methods below will seek to determine how related these two decreases are.

2.1 Long Term Trends

A common practice in financial analysis is to apply linear fits to the data, to judge whether a stock price is increasing or decreasing over a large period of time. For example, a common statistic invaluable to investors is the annual return of a stock, which compares the current price of a stock to its price one year prior. Additionally in time series analysis, it is often common practice to detrend a dataset prior to performing additions analysis procedures, as seen below.

Figure 3 plots the two datasets relative to their maximum prices. This is done in order to compare the two datasets with each other, as their average prices vary vastly. A linear fit is applied to each dataset and overplotted. To compare if each stock price was decreasing at a similar rate, the ratio between the slopes produced via linear fitting for gold price and Barrick Gold stock price was calculated, producing a value of 0.458. This value can be interpreted as a "goodness of fit" for slopes, with a value of 1.0 indicating identical decreasing rates. Thus we can infer that while the two datasets are decreasing over time, the rates (slope) at which they decrease differ. A reason for the ratio not being closer to 1.0 could be that there exists additional factors that influence the stock price. For example, the Barrick Gold Corporation also mines other metals such as copper and silver, which may have an influence on their stock price, similar to how the price of gold may influence it.

2.2 Filtering

The remaining analysis will focus on temporal shifts and prominent frequencies in the datasets. Thus, we wish to filter the data, to reduce noise and smooth the data, making it more ideal for subsequent analysis (i.e. Fourier transforming). To do this, a hanning window of the form $w_n = 1 - cos\left(2\pi\frac{n}{N}\right), 0 \leq n \leq N$ is then applied to the data. Prior to filtering however, the datasets are detrended by subtracting the linear fits calculated in §2.1.

Figure 4 overlays the two detrended and filtered datasets. The periodic similarities between the two datasets can be seen clearly here; detrending and filtering has worked well, as we can easily apply cross-correlation and Fourier transforms to determine shifts in period and peak frequencies, respectively.

2.3 Cross-Correlation

One of the questions we seek to answer is whether Barrick Gold stock price influences the price of gold or vise versa. A way to determine this is to perform a cross-correlation between the datasets, searching for trends that are time shifted. A cross-correlation is performed, resulting in the plot in Figure 5.

The curve produced indicates the likeliness of a certain time shift existing between the datasets, with the peak indicating the most likely time shift. An algorithm is applied to extract the time difference value at the peak, resulting in a value of -16.5 days. What this means is that trends that occur in Barrick Gold stock occur in gold price stock 16.5 days later. Note that the negative sign appears since we cross-correlated gold and Barrick Gold stock; the negative would not appear if Barrick Gold stock was cross-correlated with gold stock. In fact, this time shift can be seen in Figure 4, where the curve representing gold price appears slightly horizontally shifted to the right, relative to Barrick Gold stock. This is not what we initially suspected; that gold prices influence Barrick Gold stock and not vise versa.

2.4 Seasonal Trends

Since the datasets have now been detrended and filtered, we can now apply Fourier transforms to extract information about the seasonal variations or periods in the data. Figure 6 plots the Fourier transforms of said data sets. The result is an oscillating curve with various peaks at certain frequencies, where frequencies are represents in units of days^{-1}. The frequencies corresponding to the largest peaks are frequencies which are most prominent in the datasets. An algorithm was implemented to extract these prominent frequencies, by only considering peaks above a certain value (10.0 for the Fourier transform of Barrick Gold and 5.0 for

the Fourier transform of gold price). These values were chosen so as to only result in the most prominent peaks being chosen.

Some common periods of oscillations/seasonality between the two datasets are 113.08, 183.75, 367.5 and 490.0 days. The periods of 113.08 and 183.75 days do agree with our expectations. Recall in §1.3, we mentioned that gold mining can only occur during certain parts of the year, depending on location. 113.08-183.75 days corresponds to about 4-6 months; the typical range of a mining season. Upon further inspection of the raw stock data (Figures 1 and 2), there appears to exist periodicity within this range, with prices tending peak in the earlier parts of the year, dipping during the summer months, before increasing again in the later parts of the year. For a mining season ranging over the summer months (say from May to September) this is in agreement. What also makes sense is for gold prices to peak during the off-season, as mining companies (say Barrick Gold) are not able to mine during this time, resulting in gold becoming relatively more scarce, and hence more expensive, during this time.

For the larger periods of 367.5 and 490.0 days, it is difficult to determine what they correspond to, as more economic and industry effects could come into play here. For example, yearly trends or changes in the stock market could influence the price of Barrick Gold's stock, which could in turn affect the price of gold.

3 Conclusions

To summarize, we can draw several conclusions from our analysis of the relationship between stock price of the Barrick Gold Corporation and the price of gold per ounce over the last six years. Perhaps most surprisingly is that our initial expectation was incorrect; we assumed that gold prices would influence Barrick Gold stock price, but the opposite was found. In particular, trends, peaks in price, etc. that appears in Barrick Gold's stock appeared in the price of gold some 16.5 days later, as was shown in §2.3. Secondly, it was also shown in §2.1 that the general decreases in price for gold and Barrick Gold stock over the last six years were different, with Barrick Gold's stock decreasing at a larger average rate. Finally, we showed that there exists the same seasonal and yearly oscillations in the two datasets, which provides further evidence that there indeed does exist a relationship between the stock price of Barrick Gold and the price of gold per ounce.

References

[1] "*Gold Fixing Price 3:00 P.M. (London time) in London Bullion Market, based in U.S. Dollars*". Econimic Research - Federal Reserve Bank of St. Louis.

[2] *"Barrick Gold Corporation (ABX) - NYSE"*. Yahoo Finance Historical Data.

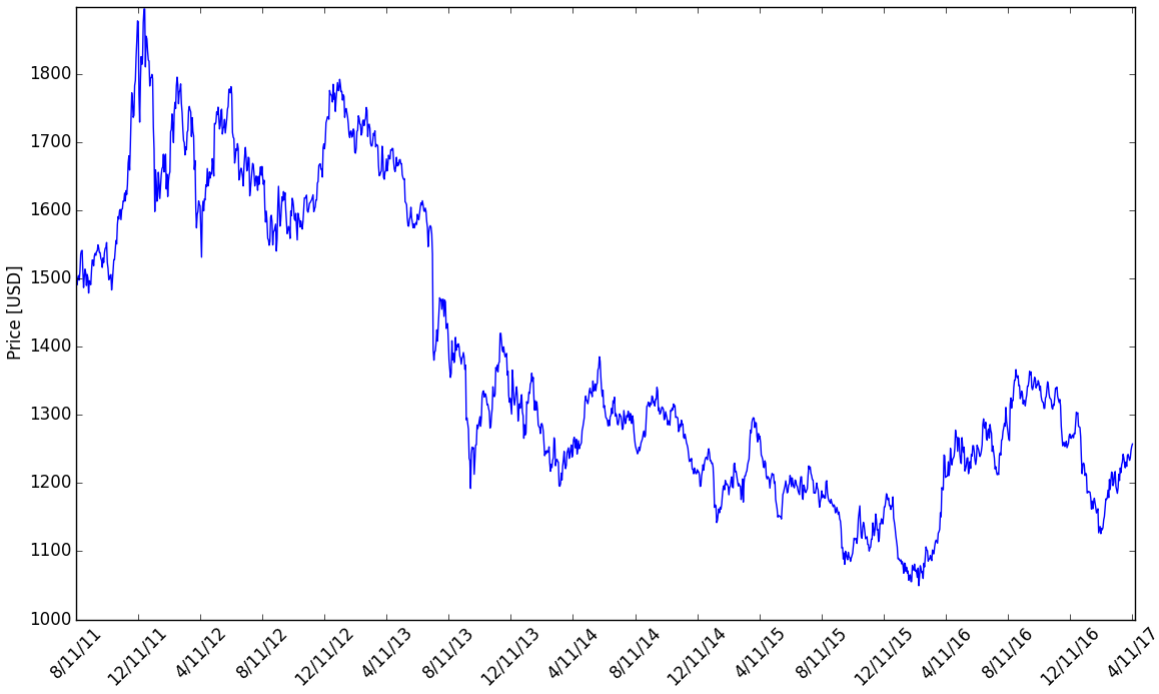

Figure 1: The price of an ounce of gold in US Dollars over the last six years

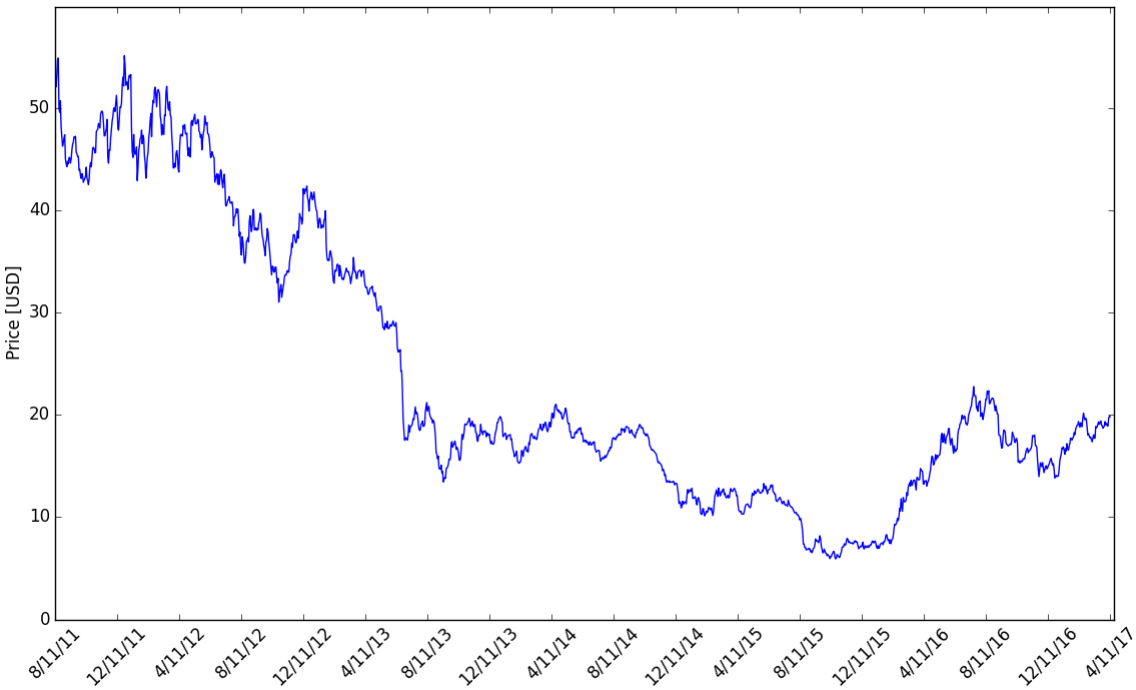

Figure 2: The stock price of the Barrick Gold Corporation (NYSE: ABX) in US Dollars over the last six years

Figure 3: Gold price per ounce and Barrick Gold stock price in USD, relative to their maximum values, overplotted with respective linear trends

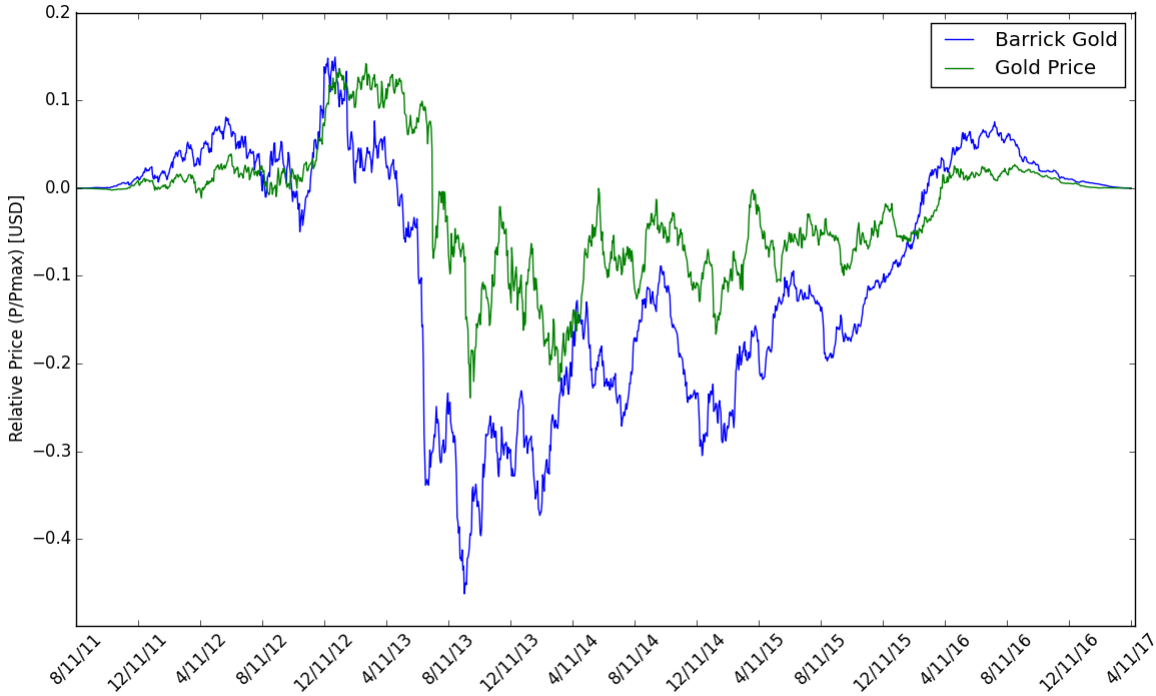

Figure 4: Detrended and filtered relative price of gold and Barrick Gold stock price. Note the stark similarities between the two plots

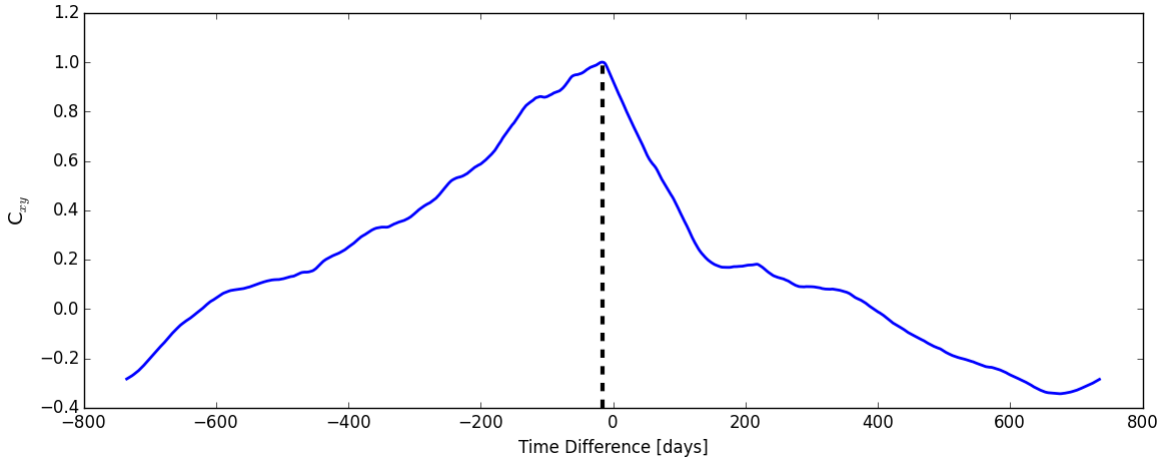

Figure 5: Cross-correlation of gold price and Barrick Gold stock price. The peak of the curve (marked by the vertical dashed line) indicates the most probable time difference; about -16.5 days

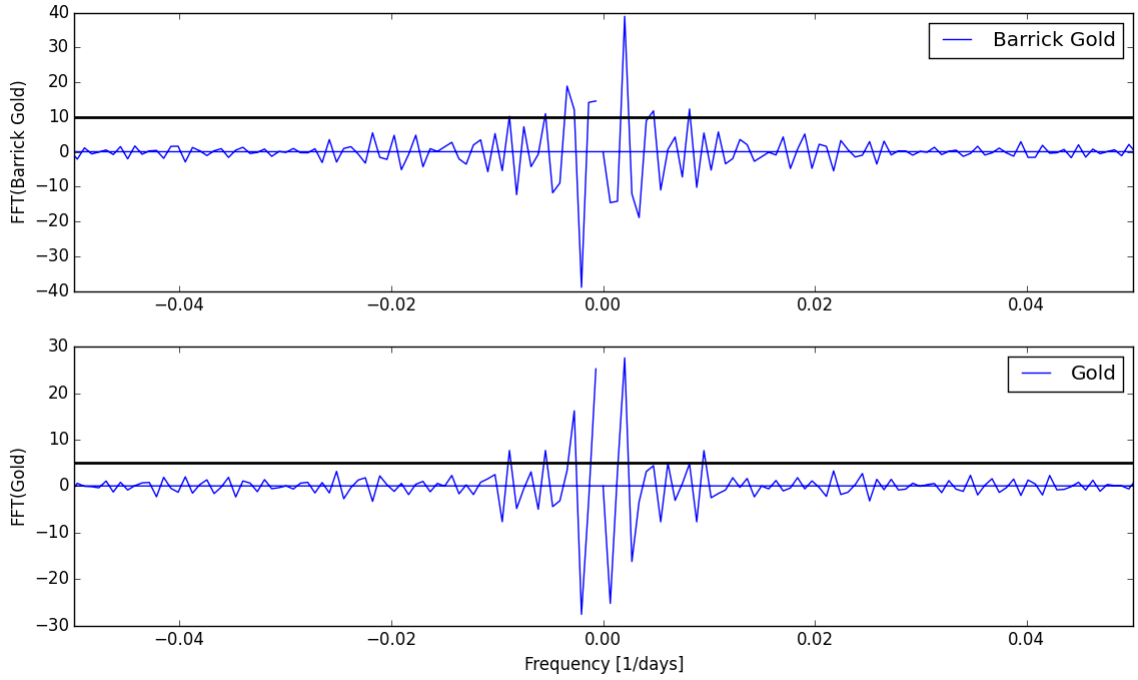

Figure 6: The Fourier transforms of gold price and Barrick Gold stock price. The horizontal line marks the cutoff point in which only peaks corresponding to frequencies above this line are considered seasonal periodic variations