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The Long-Term Relationship between Nasdaq Index and Gold Yield: Analysis Based on ARMAX Model

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Abstract: This article explores the relationship between the gold yield and the Nasdaq index through a detailed understanding of the gold yield and the changes in the Nasdaq index in the past ten years. Will the gold yield be affected by the Nasdaq index, whether there is a correlation between the two, and whether the gold price can be predicted based on the Nasdaq index. In this paper, the ARMA model is used to rank the gold return rate, and four models are used, namely the gold return rate, the gold return rate plus the Nasdaq index, the gold return rate plus the Nasdaq index lagging 1 period and lagging 2 Period to analyze and finally explore the relationship between the two. This paper mainly finds that the return rate of gold is positively correlated with the Nasdaq index, but the prediction efficiency of the model is low. Gold is an effective return to crisis industries. When the stock market is not friendly, gold can play a very good hedging role. This article uses the influential and extensive data of the Nasdaq index to let everyone know how to analyze the yield of gold through existing data. In short, it is when to buy and sell gold. This paper suggests that although the model shows that the prediction effect of the Nasdaq index on the gold return rate is not significant, the two show a positive correlation, and it has a significant effect in the lag period 1 and 2. It is recommended to use the Nasdaq index Investors who watch gold yields give priority to watching lag 1.

Keywords: gold yield, nasdaq index, ARMA model, positive correlation

1. Introduction

As the largest developing country in the world, China is also the largest industrial country and exporter. In the past few decades, China has experienced tremendous economic development, with a significant increase in per capita income and a significant increase in urbanization rate. At the same time, China has also become one of the largest trading partners in the world, and its export and import volume are among the top in the world.

However, China's economic development also has some challenges. For example, China's infrastructure and public services are still low, and environmental pollution is still serious. In addition, China's aging population is also increasing, which may have an impact on its future economic development. Nowadays, China has made some decisions to deal with these challenges, including strengthening infrastructure construction, improving public service levels, reducing environmental pollution, and promoting population policy adjustments.

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However, with the impact of covid-19, the national economy has fallen sharply, how to maintain economic resources and how to change investment thinking in the face of turbulent stock market has become a huge problem.

Gold, gold is a safe-haven investment, investors may turn to gold when the stock market is not performing well. This means that when stocks fall, gold yields are likely to rise. Also, gold yields are likely to rise when inflation rises, as gold helps investors protect their purchasing power. However, how to determine the gold yield has become a huge problem [1].

The Nasdaq Index is the market capitalization-weighted average of all stocks listed on the Nasdaq exchange, one of the most remarkable market-stocks indexes in United States and is often regarded as a mirror of the American economy. The Nasdaq index is compiled by the Nasdaq Stock Market and first released in 1971. NASDAQ exchange included all companies which listed, but not the companies of finance, insurance, and real estate. The Nasdaq index is calculated using the market capitalization weighted average method, that is, the market capitalization of each company is used to measure its contribution in the index. The value-weighted average has the advantage of being able to reflect the importance of large companies in the stock market, since larger companies generally have higher market capitalizations.

The Nasdaq is a highly liquid index that moves much faster than the S&P 500. Most of the companies included in the Nasdaq index are in industries such as technology, healthcare, consumer retail and energy. As a result, the Nasdaq is often seen as a mirror of the tech sector and the U.S. economy. The Nasdaq index is an important indicator of the US stock market, reflecting the overall changes in the stock prices of all companies which listed. The volatility of Nasdaq index can reflect the risk appetite of the market and can also serve as investors' overall assessment of the US stock market. The volatility of the Nasdaq Index may also be affected by many factors, including the economic cycle, political situation, market sentiment, etc. In the past few decades, the Nasdaq index has shown an overall upward trend, but there have been several large fluctuations in the past.

The Nasdaq index can be divided into three stages in the past 30 years. The first stage (1971-1989) is a stage of steady rise. Basically, it fluctuates up and down between 100 points and 500 points, but the overall trend is slowly upward. The second stage (1990-2000) is the stage of rapid rise. Especially since 1995, the Nasdaq index began a rapid upward trend. It surpassed 5000 points on March 9, 2000 and hit a record high of 5046.9 points on the next day (March 10) [2]. The third stage (2000-2002) is a stage of rapid decline. Since its record high in March 2000, the Nasdaq Index has begun a rapid decline, falling below 4,000 points on April 12, 2000; falling below 3,000 points on November 20; by March 12, 2001, Daily fell below 2000 points; on October 10, 2002, it reached the lowest point of 1108.49 points [3]. The fourth stage (2002-) is the slow recovery stage. Since 2002, Nasdaq has entered a slow recovery phase. After returning to 2000 points on December 29, 2003, the index has basically fluctuated between 2000 points until now.

In some studies, it has been found that there exists negative correlation between Gold Yields and Nasdaq index, which shows that when the Nasdaq index rises, gold yields may fall; when the Nasdaq index When it falls, gold yields can rise. However, there are also studies that show that there is no significant correlation between gold yields and the Nasdaq index. There are also some studies that believe that the relationship between gold yields and the Nasdaq index is complex and may be influenced by some factors, like the economic cycle, politician, and market sentiment. The views of academic circles are not uniform about the relationship between gold yield and Nasdaq index.

The correlation between gold yields and the Nasdaq can be influenced by many factors. When the market's risk appetite increases, investors may turn to gold as a safe-haven investment, which may lead to an increase in gold yields. At the same time, when the market's risk appetite declines, investors may turn to riskier investments such as stocks, which may lead to a decline in gold yields. In addition, inflation rates may also have an impact on the correlation between gold yields and the Nasdaq. Gold

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yields are likely to rise when inflation rises because gold helps investors protect their purchasing power. Overall, the correlation between gold yields and the Nasdaq is complex, not monotonous. The relationship between them may be affected by many factors, including market risk appetite, inflation rate, etc.

The next part of this article includes Literature review, including different changes in Gold Yield rate and the Nasdaq Index in the past ten years. and study the relationship between the two. The literature review is concluded at the end. Then comes the third part, with the aid of certain data and pictures, to study the correlation between the gold return rate and the Nasdaq index. Afterwards, the fourth part uses the relevant data obtained to analyze the ARMA model. Empirical analysis a. What are the similarities and differences between the conclusions of this paper and the existing literature, b. What are the research implications of this paper, c. How policy makers understand the results of research, d. How investors apply the conclusions. Finally, summarize the full text.

2. Literature Review

2.1. Gold in Past 30 Years

It is said that rare things are precious, and gold is very valuable. The total above-ground value of global gold is currently about $1.9 trillion at about $380 per troy ounce. Gold has been worth about $15 trillion in the U.S. stock market and about $22.4 trillion in the U.S. non-financial markets over the past 30 years [4]. Cumulative global gold increased from approximately 98,000 tones to 145,000 tones between 1974 and 2001; this represents a growth rate of 1.46%. As a result, global per capita gold stocks remained relatively stable during this period. Because of these data, this paper has preliminary research on the price of gold. Yet the relationship with the price of real gold and U.S. stock is inversely related to the S&P 500 rate, and therefore inversely related to the P/E ratio. Between 1957 and 1971, the IMF repeatedly sold gold to replenish its currency holdings. Between 1956 and 1960, the IMF sold some of its gold to U.S and invested. Government securities to offset its operating deficit. In 1999, the IMF used off-market gold sales to finance the IMF Engagement Initiative. In the end, the IMF sold 12.94 million ounces of gold in transactions with Brazil and Mexico [5]. In 2009, the IMF allowed the sale of 12.97 million ounces of gold. That's one-eighth of the IMF's total gold holdings. The sale is a new model that forces the IMF to remain financially sound in the long run and increase low-or-no lending to low-income countries through the PRGT. Sales started in October 2009, with transactions at the central bank and other official holders using market prices [6]. In 2010, the International Monetary Fund declared that it would conduct a marketplace sell-off within a few months to avoid market chaos. The IMF completed the sale in 2010. The IMF's gold book profit was SDR 6.85 billion, higher than forecast when the sale was approved. Using these extra profits, the IMF made its first distribution of 700 million SDRs to member countries in February 2012, which took place in October 2012. Allocation is premised on guaranteeing that at least 90% of the amount will be spent on PRGT. By the end of August 2022, about 90% of the quota has been transferred to the PRGT [7]. The Executive Board approved a second allocation of SDR 1.75 billion to the gold sales windfall proceeds reserve in September 2012, effective 2013. In 2022, 90 percent of the allocated amount is paid to the PRGT. This paper thus finds that the distribution of gold profits is a important element in increasing Lending to poor countries through PRGT [8].

2.2. Nasdaq Complex Index

Nasdaq was first proposed in 1971. After at least 30 years of development, it has become one of the largest stock markets in the world. From 1995 to 2002, the Nasdaq Composite Index started from 1000 points, rose all the way to 5000 points in less than 5 years, but quickly fell back to 1000 points in just 2 and a half years Left and right, there has been a wave of huge oscillations in the short term.

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This article briefly reviews the development and adjustment of the Nasdaq market over the years, especially between 1995 and 2002, and analyzes the causes, influences and enlightenments of its huge fluctuations. With the end of the last trading day of 2022, the Nasdaq index of US stocks also hit the worst year since the financial crisis in 2008 [9]. It fell for four quarters without exception throughout the year. first. For the whole year, the Nasdaq index has fallen by 33%, not only the largest annual decline since 2008, but also the third worst year on record. In the entire December of this year, the Nasdaq index fell by 8.7%, and the trend of capital panic fleeing intensified. The Nasdaq index is the stock price index of companies listed on the American stock exchange Nasdaq, reflecting the overall performance of the U.S. stock market. In the past ten years, the trend of the Nasdaq index has been volatile. For example, during the 2008 financial crisis, the Nasdaq fell sharply. Then, in early 2009, the Nasdaq rebounded and continued to rise in subsequent years. However, in 2018, the Nasdaq fell again and bottomed out in early 2019. Since then, the Nasdaq has rebounded again and reached an all-time high in mid-2020. In general, the trend of the Nasdaq index is volatile, and there has been no continuous long-term upward or downward trend in the past ten years. This may be due to the influence of many factors, including economic cycles, policy changes, company performance, market confidence [10].

3. Research Design

3.1. Data Source and ADF Test

This article searches Yahoo for the gold price from 2009 to the present, and the Nasdaq index from 2009 to the present. By merging the two data, the ARMA model is used to estimate the relationship between the two, so as to further explore the relationship between gold yield and the relationship between the NASDAQ indices.

By doing the root test on the model, assume the original hypothesis is that the model is not smooth. After putting the data into Stata and performing the ADF test, it can be seen from Table 1 that the p-value of Gold and Nasdaq is 0, since it less than 0.1 which represent the model is stable and feasible.

Table 1: ADF test.

Variables	t-statistic	p-value
	Raw	
Gold	-2.606	0.2773
Nasdaq	-2.085	0.5547
	Difference	
Gold	-38.748	0.0000
Nasdaq	-40.274	0.0000

3.2. ARMA

ARMA is a statistical model used to describe time series data and predict future values. ARMA models consist of autoregressive and moving average. The autoregressive part means that the value at the current moment is related to the value at some previous moment. It is represented by a polynomial of order n, namely the AR(n) model. The moving average part indicates that the value at the current moment is related to the sum of errors at some previous moments. It is represented by a polynomial of order q, namely the MA(q) model. In summary, the ARMA (p, q) model indicates that the current moment value is related to the sum of the previous p moment values and q moment errors. By fitting parameters to historical data, ARMA models can be used to predict future time series data.

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The autoregressive model part represents the relationship between the data points at the current moment and the data points at the previous moment. The form of the autoregressive model part is:

$$X_t = c + \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + \cdots + \Phi_p X_{t-p} + \varepsilon_t \quad (1)$$

The moving average model part represents the relationship between the data point at the current moment and the error term. The form of the moving average model part is:

$$X_t = \mu + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \quad (2)$$

The form of the ARMA model is:

$$X_t = c + \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + \cdots + \Phi_p X_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \quad (3)$$

Where X_t is the time series data, c is the constant term, $\Phi_1, \Phi_2, \ldots, \Phi_p$ are the autoregressive coefficients, ε_t is the error term, $\theta_1, \theta_2, \ldots, \theta_q$ are the moving average coefficients. The ARMA model has two parameters p, q, which respectively represent the number of autoregressive items and the number of moving average items, so the common ARMA (p, q) model.

$$x_t = \emptyset_0 + \sum_{i=1}^{p} \emptyset_i x_{t-i} + \alpha_i - \sum_{i=1}^{q} \emptyset_i \alpha_{t-i} \quad (4)$$

The thinking of the AR model is not hard. It believes that the current time point can be predicted by adding white noise to the linear combination of the past time points of the time series. It is a random simple extension. MA is essentially the same as AR. It is not a linear combination of time series, but a linear combination of white noise. The biggest difference from AR is that the influence of white noise in the AR model does not directly affect the current forecast value, but an indirect one. The ARMA model can be derived jointly by adding the AR and MA models.

4. Results and Analysis

4.1. PACF and ACF

PACF (Partial Autocorrelation Function) is the abbreviation of partial autocorrelation function. It is the autocorrelation coefficient used to analyze time series data. In a time series, if there is a correlation between x_t and x_{t-k}, then there will be a correlation between x_{t-1} and x_{t-k-1}. This correlation is called autocorrelation. The autocorrelation coefficient can be used to measure the correlation between two data points to infer the trend and periodicity of the data. Partial autocorrelation function (PACF) is a method used to evaluate autocorrelation, it is used to evaluate the correlation between x_t and x_{t-k}, in this case, x_{t-1} and x_{t-k-1} The correlation between them is ignored. Autocorrelations in time series data can be more accurately identified using PACF, allowing for better inference of time series data characteristics such as trend and periodicity. When building a time series model, PACF is an important reference for determining the number of autoregressive items p of the model.

ACF is the abbreviation of Autocorrelation Function, also known as autocorrelation function, which is used to analyze the autocorrelation coefficient of time series data. In a time, series, if there is a correlation between x_t and x_{t-k}, then there will be a correlation between x_{t-1} and x_{t-k-1}. This correlation is called autocorrelation. The autocorrelation coefficient can be used to measure the

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correlation between two data points to infer the trend and periodicity of the data. ACF is a method used to evaluate the correlation between x_t and x_{t-k}, it gives the correlation between x_t and any x_{t-k} and can be used to explore the autocorrelation of time series data. Through the value of ACF, you can judge whether the time series data has a trend or periodicity. When building a time series model, ACF is an important reference for determining the number of moving average items q of the model.

From the fixed order result of the two images in the first row in Figure 1, the first part beyond the x-axis is 1, but 2 and 3 also remarkable, so the order is ARIMA (3, 1, 3).

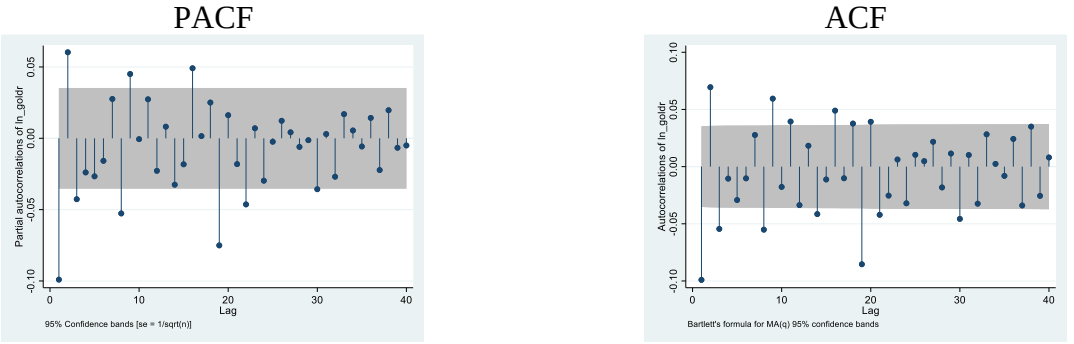

Figure 1: PACF and ACF.

The validity of the model can be explained by testing the residuals. The normality test of the residuals: check whether the residuals conform to the normal distribution. If they conform to the normal distribution, it indicates that the model fits the data better. Homogeneity of residual variance test: Check whether the variance of the residual is homogeneous. If the variance is homogeneous, it means that the model fits the data better. Residual autocorrelation test: Check whether the residuals have autocorrelation. If there is no autocorrelation, it means that the model fits the data better. If the residuals meet the above assumptions, it means that the model fits well and is reliable for future predictions, so the model is valid. Conversely, if the residuals do not meet the assumptions, it indicates that the model fit is poor and the prediction for the future is not reliable, so the model is invalid (Table 2). Model 1 is an ARMA modeling of gold returns. Model 2 is ARMA's modeling of the return on gold after adding the Nasdaq index. Model 3 is ARMA's modeling of the Nasdaq index lagging 1 period and gold yield. Model 4 is ARMA's modeling of the Nasdaq index lagging 2 and gold yield. Here the null hypothesis of our residual test is: the sequence is white noise. Through inspection, this part found that the sequence is indeed white noise.

Table 2: Residual test.

Model	Portmanteau (Q) statistic	Prob > chi2
1	52.6171	0.0873
2	53.1110	0.0802
3	53.4963	0.0751
4	53.4449	0.0757

4.2. Estimation Results

According to the estimation results from Table 3, when T=0, the p value is 0.216, when T=-1, the p value is 0.001, when T = -2, the p value is 0.448. From the data, it can be found that the timely increase of the Nasdaq index in ARMA has not played a decisive role in the gold yield forecast. Of

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course, the Nasdaq has shown positive correlations with gold yields, but these positive correlations have a lagged effect. The effect is particularly significant when lagging for 1 period. Although it has an effect after lagging for 2 periods, it is not as big as the impact of period 1.

Table 3: ARMAX model estimation results.

	(1)	(2)	(3)	(4)
	Model 1	Model 2	Model 3	Model 4
AR				
L1	-0.8659	0.0310	-0.8690	-0.8697
	0.000	0.000	0.000	0.000
L2	0.7965231	0.7948076	0.7905575	0.7890713
	0.000	0.000	0.000	0.000
L3	0.8817292	0.8804954	0.8768479	0.876453
	0.000	0.000	0.000	0.000
MA				
L1	0.7963652	0.7962706	0.7992757	0.7997809
	0.000	0.000	0.000	0.000
L2	-0.8446496	-0.8157641	-0.8128469	-0.8111709
	0.000	0.000	0.000	0.000
L3	-0.8446496	-0.8431164	-0.8394481	-0.8392346
	0.000	0.000	0.000	0.000
Nasdaq				
T=0		0.0202288	0.0201645	0.0206453
		0.219	0.226	0.216
T=-1			0.0604348	0.0604482
			0.001	0.001
T=-2				0.0141606
				0.448
Constant	0.0005	0.0004954	0.0004812	0.0004784
	0.015	0.016	0.022	0.024

Mean Absolute Error (MAE) is a commonly used indicator for evaluating the prediction accuracy of regression models. It measures the mean absolute error between the predicted value and the true value. The formula is: $MAE = (1/n)\Sigma|y - \hat{y}|$. The smaller the MAE, the smaller the error between the predicted value and the true value. Here the MAE values are almost around 62 (please see Table 4). From this it can be seen that the efficiency of this model is not very high.

Table 4: Efficiency.

Model	MAE
1	62.652954
2	62.615207
3	62.666021
4	62.688492

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5. Conclusion

Gold is an efficient and expensive asset. When people want to buy and decide whether to buy gold at a certain stage through market analysis, they need to study the yield of gold. Gold yield refers to the rate of return generated by investing in gold. It is usually expressed in the form of annualized rate of return, which means the income earned by gold investment in one year. Gold yield can be obtained by buying gold products, such as gold bars, gold commemorative coins, etc., or investing in gold trading funds (ETF). The rate of return on these investments may vary due to market fluctuations. As a safe-haven asset, the price of gold is usually opposite to that of other financial assets, rising when the economy is unstable and falling when the economy is stable. Therefore, gold yields are generally considered to be volatile. How to compare the market has become a problem. Here the NASDAQ index is the object selected in this paper. NASDAQ Index is a kind of marketplace capitalization-weighted index listed in the United States. It reflects the average stock price of companies listed on the NASDAQ stock exchange. The Nasdaq index is primarily used to measure the market performance of companies listed on the Nasdaq stock exchange. Investors can understand the overall performance of companies listed on the Nasdaq stock exchange by observing the changes in the Nasdaq index. It can also be used to refer to the overall development of the US economy. The Nasdaq index is also one of the important investment indicators. Investors can allocate assets by investing in Nasdaq index funds (ETFs). It can also be used to measure the performance gap between individual stocks and the Nasdaq index. This article uses a large amount of data and modeling to analyze the relationship between gold yield and the Nasdaq index. The central idea and purpose of this article is to explore the relationship between gold yield and Nasdaq index. This article predicts through the ARMA model, observes PACF and ACF, and discovers through the MAE table. After using ARMA modeling, this paper found that although the Nasdaq index and the gold yield showed a positive correlation, it had a lagging effect, specifically showing that the results of the first and second lags were more significant. But in terms of the efficiency of the model, adding the Nasdaq index does not effectively increase the prediction efficiency of the model. Although the Nasdaq index does not have a huge predictive impact on the yield of gold, people can influence and understand the price of gold and changes in the yield of gold to a certain extent by analyzing the world economic situation through the Nasdaq index. New forecasting efficiencies can be explored later with the S&P 500 or even other data.

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