Are Precious Metals a Good Hedge Against Inflation in The Netherlands?

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ABSTRACT,
This study tests the hedging ability of four primary precious metals (Gold, Silver, Platinum, and Palladium) with short-term investment horizons in the Netherlands. This study also compares the hedging ability of these precious metals between the covid period and the no-covid period. We found that these precious metals do not have inflation hedging ability with short-term investment horizons in the Netherlands. It is not wise for investors who want to hedge inflation to invest in precious metals in the Netherlands.

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1. INTRODUCTION

In early 2020, the coronavirus was discovered and quickly swept the world. Many people got sick, and some of them even lost their lives. The pandemic has caused severe damage to not only our health but also the economy. Small companies went bankrupt, factories closed, and workers lost their jobs. Governments strictly control their borders, and people cannot travel abroad as easy as before. Most countries had negative economic growth in 2020. For example, the Netherlands had a GDP growth rate of -3.8% that year (Word Bank, 2022).

The spread of the coronavirus is an obstacle to global trade. Supply chains and logistics have been dramatically affected, leading to the higher cost of products. According to the Dutch Central Bureau of Statistics (2022), the Consumer Price Index (CPI) for November 2021 was 5.2 per cent higher than last year's same month, and that month's inflation rate was the highest in the previous forty years.

Dutch investors want to invest smarter to cope with high inflation. A rising CPI means average living costs are increasing. In other words, the same amount of money can only buy fewer commodities compared before (Cunado & Perez de Gracia, 2005). If people do not invest or make wrong decisions, their wealth will gradually shrink. Investors would like to choose assets with solid inflation hedging ability to prevent hidden loss in a high inflation period. Many investors consider precious metals, especially gold, a good tool against inflation.

Gold, silver, platinum, and palladium are the most common precious metals. These resources are limited and scarce, and they have a variety of uses. They can be made into jewellery and used in many industrial processes (Ciner, 2001). They are unique commodities because they also have some properties that ordinary goods do not have (Salant & Henderson, 1978). For example, gold and silver were used as money in many countries long ago. They are durable and can be stored forever without going bad like wheat or soybean. Precious metals are easily authenticated and accepted worldwide (Worthington & Pahlavani, 2007).

We can invest in precious metals in many ways, such as bullion, jewellery, mutual funds, ETFs, and stocks of mining companies. This study will choose ETFs and Spot Prices to study the hedging ability of precious metals. ETFs are a popular investment vehicle that combines the advantages of both open-ended and closed-end funds (Da & Shive, 2018). The cost of ETFs is low compared with open-ended funds, and ETFs are more flexible than closed-ended funds (Da & Shive, 2018). The Spot Price is the current price of an asset, and they are an essential price indicator for future contracts (Ghosh et al., 2001). Therefore, It is meaningful to use these two types of prices to analyse the hedging ability of precious metals.

This research aims to assess the inflation hedging ability of gold, silver, platinum, and palladium in the Netherlands. The results of this research are of interest to Dutch investors, especially those risk-averse and who do not want their assets to depreciate.

In addition, we are interested in the performance of precious metals during the covid period. Although the Dutch government has lifted all measures for covid, according to recent reports from the RIVM (2022), they predict that the covid outbreak will happen again soon. These past two years during the covid (2020-2022) have been a period of high inflation. According to the CBS (2022), the Dutch CPI was only 105.24 in February 2020, while 114.4 in February 2022, an increase of 8.7% during this period. In comparison, from February 2018 to February 2020, the CPI only increased by 2.5%. We want to know whether these precious metals perform better or worse during the covid than the period without covid.

Precious metals have always been a popular research subject, and we found the following gaps during the literature review. The first gap is that most scholars chose the United States, the United Kingdom, Japan, and Germany to research. Few researchers investigated the hedging ability of precious metals in the Netherlands. Many scholars believe that precious metals have different hedging abilities in various countries (Rubbaniy et al., 2011). Although gold prices are the same worldwide, the CPI varies from country to country. For example, although the USA and the Netherlands are both developed western capitalist countries, the inflation rate in these two countries are not the same. According to the United States Bureau of Statistics (2022), CPI increased 30.75% from 2011 to 2022 in the US, and CPI only increased by 18.75% during the same period in the Netherlands (CBS, 2022). The second gap we found is that the conclusions of precious metals' hedging ability from different researchers are inconsistent. Some researchers believe that precious metals have a strong hedging ability. However, other researchers argue that precious metals cannot be against inflation (Mahdavi & Zhou, 1997). The third gap is that many scholars are only interested in gold, and not much research has been done on silver, platinum, and palladium (Rubbaniy et al., 2011). The last gap is that few papers assess the hedging ability of precious metals during the covid period. These papers Akhtaruzzaman et al. (2020) and Gomis-Porqueras et al. (2021) only investigated the hedging ability of gold during the first few months of the covid period.

This paper contributes to the literature in the following ways. This paper will choose the Netherlands to study; This paper will assess the hedging potential of these four precious metals (gold, silver, platinum, and palladium) at the same time and examine their effectiveness during the covid period from December 2019 to February 2022 and compare them with a no-covid; We test their effectiveness based on two different prices (Spot Prices, ETFs Prices). As mentioned earlier, these two prices are both essential to investors, and maybe the hedging ability from different prices is different.

To achieve the goals indicated above. We ask two research questions.

Research question One (RQ1): In the Netherlands, are precious metals (gold, silver, platinum, and palladium) a good hedge against inflation with short-term investment horizons?

Research question Two (RQ2): In the Netherlands and during the covid period, are precious metals (gold, silver, platinum, and palladium) a good hedge against inflation with one-month investment horizons?

There are many measures to test the hedging ability. We will discuss four popular measures (Fisher coefficient by Fama and Schwert (1977), Hedging demand by Schotman and Schweitzer (2000), Hedge ratio and the Pearson correlation coefficient between inflation and nominal asset returns by Bodie (1976, 1982). Their advantages and the connections between them will also be discussed. After comparison, we choose to use the Pearson correlation coefficient introduced by Bodie (1982). We perform correlation t-tests to find whether there is a significant linear correlation between CPI returns and asset returns.

There are two main findings of this paper, and they answered the two research questions we asked before. The first finding is that gold, silver, platinum, and palladium do not have hedging ability with short-term investment horizons in the Netherlands. The second finding is that during the covid period, the hedging ability of these four precious metals remains very weak.

This paper is organized in the following way. The first chapter is the introduction. The second chapter is a brief literature review, and it will summarise the past research on the hedging ability of these metals. The third chapter formulates four hypotheses based on the literature review. The fourth chapter is to build a conceptual framework. This chapter explains what inflation-hedging is and the four measures to test the hedging ability of an asset. The fifth chapter describes the data and methodology we will use. The sixth chapter is to evaluate the Null hypotheses and present the results of the hypotheses. The seventh chapter includes the conclusions, limitations, and future research recommendations. The eighth chapter is the references, and the last two chapters are appendices.

2. LITERATURE REVIEW

As mentioned earlier, many studies have investigated the hedging ability of precious metals. However, the results are not very consistent. Taylor (1998) claimed precious metals (gold, silver, platinum, and palladium) could be used as a long-run inflation hedge in the United States, and these precious metals offer minor protection against short-run (monthly) movements in the inflation rate of the United States. Rubbaniy et al. (2011) researched the hedging ability of gold, silver, and platinum in Germany. They argued that investors in Germany could hedge against inflation by investing in gold. Gold is the only metal with the inflation hedging ability. Silver and platinum do not hedge for inflation in Germany.

Although there is a lot of published research on the hedging ability of precious metals, most literature only analyses the hedging ability of gold. Because of its durability, acceptance, and liquidity, gold is a unique commodity and relatively easy to verify and transport (Worthington & Pahlavani, 2007). Ghosh et al. (2001) also found that many short-run movements in the price of gold are consistent with the general inflation rate. They also indicated that gold could be regarded as a long-run inflation hedge. Worthington and Pahlavani (2007) argued that the inflation hedging quality of gold depends on the presence of a stable long-term relationship between the price of gold and the inflation rate. They found the price of gold is solidly cointegrated with the CPI, which means the price of gold and CPI share the same trend. Therefore, they argued that gold was a helpful inflation hedge in the post-1970s period in the United States. However, Mahdavi and Zhou (1997) indicated no cointegration relationship between the price of gold and the CPI between 1970 and 1994.

Some scholars believe that gold has different inflation hedging capabilities in various countries. Chua and Woodward (2006) investigated the effectiveness of gold as an inflation hedge in six major industrial countries[1] from 1975 to 1980. They found that gold has been an effective hedge only in the US for investors with investment horizons of one and six months. The returns on gold were not systematically related to the inflation rates in the remaining five countries. Beckmann and Czudaj (2013) indicated that gold could partially hedge future inflation in the long run, and the hedging ability of gold is more powerful for the USA and the UK than for Japan and Europe.

Few papers investigated the performance of precious metals during the covid period. Gomis-Porqueras et al. (2021) examined the effectiveness of gold as a hedging instrument when investors are faced with currency, European sovereign debt, stock market, and oil inflation risks. They found compelling evidence that gold is a universal hedge during crises, including the covid pandemic. Akhtaruzzaman et al. (2020) examined the role of gold as a hedge asset in different periods of the covid crisis. The first period is from December 31, 2019, to March 16, 2020, and the second period is from March 17 to April 24, 2020. Akhtaruzzaman et al. (2020) indicated that gold was a good hedging strategy only during the first period.

3. HYPOTHESIS

Based on the literature review and our research questions, we formulate four hypotheses.

Several articles indicated that gold is good at hedging inflation (Ghosh et al., 2001; Worthington & Pahlavani, 2007).

Hypothesis One (H1): In the Netherlands, gold has a strong hedging ability with short-term investment horizons.

Many articles indicated that silver, platinum, and palladium are poor at hedging inflation (Rubbaniy et al., 2011; Taylor, 1998).

Hypothesis Two(H2): In the Netherlands, silver, platinum, and palladium do not have hedging ability with short-term investment horizons.

Akhtaruzzaman et al. (2020) indicated that gold lost its hedging ability during the covid period. Therefore, we develop Hypothesis Three (H3) to test the hedging ability of these four precious metals during the covid period.

Hypothesis Three(H3): In the Netherlands, precious metals have a lower hedging ability during the covid period.

Spierdijk and Umar (2013) uses the ETF[2] to assess the hedging potential of precious metals. S&P GSCI includes five groups of commodity futures contracts, one of which is precious metals. Spierdijk and Umar (2013) indicated that they do not find any evidence for a significant hedging ability of precious metals. However, (Taylor, 1998) got different results by using the spot prices of precious metals to test the hedging ability.

Hypothesis Four(H4): In the Netherlands, the hedging ability of precious metals-related ETFs is different from the Spot Price of precious metals.

4. CONCEPTUAL FRAMEWORK

This study is going to test the inflation hedging ability of precious metals. There are several approaches to determine. Spierdijk and Umar (2013) summarised four inflation-hedging measures: the Pearson correlation coefficient, the Hedge ratio, and the Cost of hedging by Bodie (1976, 1982), the Fisher coefficient by Fama and Schwert (1977), and the Hedging demand ratio by Schotman and Schweitzer (2000). Pearson correlation coefficient is related to the other three measures. The Fisher coefficient and the hedging demand can be represented by the product of a positive scalar and the Pearson correlation coefficient (Spierdijk & Umar, 2013). The hedge ratio and the squared correlation coefficient add up to one (Spierdijk & Umar, 2013). In this chapter, we will explain how to quantify the inflation-hedging capabilities and discuss the relationship between these four measures in detail.

We'll begin with some basic notation. We use a k-period investment horizon and concentrate on simple k-period asset returns and inflation rates. We denote the k-period nominal returns of a risky asset from time t to time t + k as $R_{r,t}^{(k)}$, and real returns over the same interval are represented by $r_{r,t}^{(k)}$. The inflation rate from time t to t + k is $\pi_t^{(k)}$.

4.1 Inflation and CPI

According to the International Monetary Fund (2022), inflation is the rate at which prices rise over time. Inflation is usually defined as a broad measure of price increases or increases in the cost of living in a country.

According to Organization for Economic Co-operation and Development (2022), the consumer price index (CPI) indicates inflation. It assesses living standards changes by tracking

[1] The six countries are Canada, Germany, Japan, Switzerland, the UK, and the USA.

[2] The ETF is iShares S&P GSCI

differences in the prices of a basket of goods and services that specific categories of families frequently purchase.

4.2 The Pearson Correlation Coefficient

Bodie (1982) uses the Pearson Correlation Coefficient (ρ) to measure the hedging ability of an asset. Bodie (1982) indicated that $S= 1 - \rho^2$. For examples, when $\rho = \pm 1$ and $S = 0$, it means the variance of the real return of the GMV portfolio is zero, and the GMV portfolio does not have any risks. In other words, the risky asset we add can hedge all the risk. when $\rho = 0.1$ and $S = 0.99$, It means the GMV portfolio's real return variance is just a little less than the risk-free portfolio's real return variance. In other words, the risk only decreases a bit, and the risky asset we add can hedge very less inflation risk.

From these two examples, we can see that the squared correlation coefficient can also reflect the maximum possible decrease of the variance of the real return of the risk-free portfolio (Bodie, 1982).

$$(1)\ \rho = \mathrm{Corr}\left[R_{r,t}^{(k)}, \pi_t^{(k)}\right]$$

Pearson Correlation coefficient ρ refers to the strength of a linear relationship between the CPI returns and nominal returns of this asset (see equation 1). The absolute value of ρ is between 0 and 1. ρ equals 0 means non-hedge, and ρ equals one means perfect hedge. An asset is a better hedge against inflation when the absolute value of ρ is higher.

4.3 Other Three Measures

These three measures (The Hedge ratio and the Cost of hedging, the Fisher coefficient, and the Hedging demand ratio) are discussed in detail in the appendices A.

4.4 The Relation Between These Measures

The Pearson correlation coefficient is calculated in this way (see equation 2).

$$(2)\ \rho = \mathrm{Corr}\left[R_{r,t}^{(k)}, \pi_t^{(k)}\right] = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

x_i: Returns of the inflation rates from time t to t + k.
y_i: The nominal return of a risky asset from time t to t + k.
$\bar{x}$: Mean of the returns of the inflation rates from time t to t + k.
$\bar{y}$: Mean of the nominal return of an asset from time t to t + k.

It is easy to find that the Hedging demand by Schotman and Schweitzer (2000) can be represented by Correlation Coefficient multiple a scalar (See equation 3).

$$(3)\ \Delta^{(k)} = \frac{\mathrm{Cov}[R_{r,t}^{(k)}, \pi_t^{(k)}]}{\mathrm{Var}[R_{r,t}^{(k)}]} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(y_i - \bar{y})^2} = \rho * \sqrt{\frac{\sum(x_i - \bar{x})^2}{\sum(y_i - \bar{y})^2}} = \rho * \sqrt{\frac{\mathrm{var}[\pi_t^{(k)}]}{\mathrm{var}[R_{r,t}^{(k)}]}}$$

According to Bodie (1982), the hedge ratio (S) can be expressed in terms of Correlation Coefficient (See equation 4).

$$(4)\ S = 1 - \rho^2$$

The regression coefficient is calculated by dividing the covariance between $R_{r,t}^{(k)}$ and $\pi_t^{(k)}$ by the variance of $R_{r,t}^{(k)}$ (See equation 5 & 6).

$$(5)\ R_{r,t}^{(k)} = \mu + \beta\pi_t^{(k)} + \varepsilon$$

$$(6)\ \beta_t^{(k)} = \frac{\mathrm{Cov}[R_t^{(k)}, \pi_t^{(k)}]}{\mathrm{var}[R_t^{(k)}]} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2}$$

We found that $\beta_t^{(k)}$ can also be expressed by Correlation Coefficient multiple a scaler (See equation 7).

$$(7)\ \beta^{(k)} = \rho * \sqrt{\frac{\sum(y_i - \bar{y})^2}{\sum(x_i - \bar{x})^2}} = \rho * \sqrt{\frac{\mathrm{var}\left[R_{r,t}^{(k)}\right]}{\mathrm{var}\left[\pi_t^{(k)}\right]}}$$

In conclusion, the last three methods all can be expressed in terms of the Correlation coefficient(ρ).

4.5 The Measure This Study Will Use

This paper will use the Person correlation coefficient to test the hedging ability. Various hedging measures have a risk of getting contradictory outcomes on the hedging ability of an asset, and it is hard for us to conclude; We can use SPSS software to calculate the correlation coefficient and perform hypothesis tests efficiently; The inflation-hedging measure is based on the mean-variance investment theory, and the correlation coefficient is scale-free, allowing for comparisons across assets, sample periods, and investment horizons (Spierdijk & Umar, 2013). As mentioned before, The Pearson correlation coefficient is related to all three other measures. Therefore, this is the most appropriate measure to choose.

5. DATA AND METHODOLOGY

5.1 Data This Study Will Use

5.1.1 CPI

The inflation series this study chooses to use is the Netherlands. As mentioned in the literature review, only a few researchers investigated the hedging ability of precious metals in the Netherlands.

This study will use the return in CPI (%) to represent the change in monthly inflation (see equation 8). For example, if the CPI of the 8th month is 80, the CPI of the 9th month is 100, and the investment horizon is one month. The return in CPI for this example is 25%.

$$(8)\ \frac{\text{CPI of month}_n - \text{CPI of month}_{n-x}}{\text{CPI of month}_{n-x}} = \text{Return in CPI (\%)}$$

n: The last month of this period
x: The investment horizon

The monthly CPI can be downloaded from the official website of the Netherlands Central Bureau of Statistics (CBS). This data's frequency is monthly, which is the highest frequency we can use.

5.1.2 Spot Price

According to Black (1976), the price at which a security can currently be bought or sold at a specific location and time is known as the "spot price." The data source is London Bullion Market Association (LMBA). LMBA is an international trade organization representing the global Over the Counter (OTC) bullion market.

The currency of the spot price is Euro because the inflation series we choose is the Netherlands. The frequency of the data is monthly.

5.1.3 ETFs

The study chooses one representative ETF for every precious metal. These four ETFs we choose all have a high market share and relatively long history, and they are ideal financial products for passively managed investors(Da & Shive, 2018). They closely track movements in the price of precious metals. Investors can invest in these precious metals without really buying physical products, and they can buy or sell ETFs in the same way they do in stocks(Hillier et al., 2006). The table below lists the ETFs selected for this study. The data source is Refinitiv Eikon, the currency is the euro, and the data frequency is monthly.

Table 1. Four ETFs We Use

Name	Short description
1. SPDR Gold Shares (GLD)	GLD is the largest physically backed gold exchange-traded fund (ETF) in the world and is managed by State Street Global Advisors, and it reflects the performance of gold.
2. iShares Silver Trust (SLV)	SLV is the largest silver ETF in the market and one of the ETFs administered by BlackRock. It generally reflects the performance of the price of silver.
3. Abrdn Physical Platinum Shares ETF (PPLT.K)	PPLT.K is the largest Platinum ETF, and it reflects the performance of the price of physical platinum. Abrdn manages it, and according to their official website (2022), this ETF is designed for investors who want a cost-effective and convenient method to invest in physical platinum.
4. Abrdn Physical Palladium Shares ETF (PALL.K)	PALL.K is managed by Abrdn, and it seeks to reflect the performance of the price of palladium.

5.1.4 Simple return

We need to convert the ETFs' prices and Spot Prices to the return (%). This paper uses the Pearson correlation coefficient to test the hedging ability, and this measure focuses on the strength of the linear relationship between two variables. Like what we do to the data of CPI, we convert these prices to simple returns. A simple rate of return is computed by deducting the investment's initial value from its current value and dividing the result by the initial value (see equation 9).

$$(9)\quad \frac{\text{Price}_n - \text{Price}_{n-x}}{\text{Price}_{n-x}} = \text{Simple Return (\%)}$$

x: The investment horizon.
Price_n: The price of this security at the end of month n.
Price_{n-x} : The price of this security at the end of month n-x.

For example, if the price of ETF A at the end of March is 100$, the price at the end of January is 80$. The investment horizon is two months, and the simple return is 25%.

5.2 Sample Period

In Chapter 3, we developed several hypotheses. To test them, we choose three periods for sampling.

Period One (P1): From 2010 March to 2022 February.

The sample period one (P1) is used to test Hypothesis One (H1) and Hypothesis two(H2). The sample size should be as large as possible to make our results more convincing. Two ETFs (PPLT.K and PALL.K) launched in 2010, meaning P1 can only start from March 2010. The total length of P1 is 144 months.

Period Two (P2): Covid Period, From 2019 December to 2022 February.

Period Three (P3): No-covid Period, From 2017 September to 2019 November.

Period Two (P2) and Period Three (P3) are used for Hypothesis Three(H3). H3 examines the effectiveness of these precious metals as a hedging instrument during the Covid period. The beginning of P2 is December 2019 because the first covid case was found in that month. This study wants to examine how these assets behaved under the influence of the covid. P2 ends in February 2022 because Russia invaded Ukraine at the end of that month and the sharp rise in Consumer Price Index (CPI) from 2022 March was mainly due to the war in Ukraine (CBS,2022). According to CBS (2022), Russia plays a significant role in energy and agriculture. After the war outbreak, many countries began to boycott Russia. They imposed an economic blockade on Russia and stopped global trade with them. Prices of many goods began to rise rapidly.

The total length of P3 is 27 months. And it has the same size as P2 so that we can compare the effectiveness of these precious metals between the covid period and no covid period.

5.3 Sample Size

There are 144 months in Period One (P1). This study focuses on short-term investments. Therefore, the investment horizons we choose are one, two, three, four, five and six months. Six months is the biggest investment horizon we can use. If we choose a longer investment horizon, The sample size will be too small to calculate the correlation coefficient. For example, if the investment horizon is two years, the sample size will be five.
The biggest sample size is 144, and the smallest is 24 (See Table 2). We chose six investment horizons for period one (P1) to see if the results would differ for different short-term investment horizons.

Table 2. Sample Size for Period One

Investment horizons	Same size
One Month	144
Two Month	72
Three Month	48
Four Month	36
Five Month	28
Six Month	24

There are only 27 months in Period Two (P2) and Period Three (P3). Therefore, we focus on one-month investment horizons during these two periods, and the sample sizes are 27.

5.4 The Descriptive Statistics

5.4.1 Period One(P1)

During period one(P1), The average return of CPI is 0.15% per month, with a standard deviation of 0.51%. Gold Spot Price is the most stable compared with other precious metals, with a standard deviation of 3.4%. The average monthly return of PPLT.K (A platinum-related ETF) and the Spot Price of platinum are negative. The average monthly returns of the other three precious metals are all positive. SLV and PALL.K are not stable compared with others. These two assets' monthly return standard deviation is 8.56% and 8.17%. The maximum monthly return of PALL.K is 28.7%, and the minimum monthly return is - 21.3% (The detailed statistics are displayed in table 3 in the Appendices B).

The spot price of any precious metals has the same trend as its related ETF (See Figure 1 in the Appendices B). Monthly returns of the spot prices of any precious metals are highly overlapped with the monthly return of its related ETFs (See figures 3,4,5, and 6 in the Appendices B).

5.4.2 Covid Period(P2) & No-covid Period(P3)

The monthly return of CPI during the covid period (0.3%) is higher than No-covid period (0.1%). Every precious metal's monthly return standard deviation during the covid period is larger than No-covid period (See table 4 in the Appendices B).

Any precious metal's spot price follows the same trend as its corresponding ETF (See Figure 2 in the Appendices B). There is a significant overlap between the monthly returns of the relevant ETFs and the monthly returns of the spot prices of any precious metals (See figures 3,4,5 and 6 in the Appendices B).

5.5 Methodology

As mentioned before, this study will use the Pearson Correlation Coefficient ρ to test the hedging ability of these precious metals. The strength of a linear relationship between the CPI returns and returns of the tested asset is represented by the Pearson Correlation Coefficient ρ (See equation 1 above). The range of the absolute value of ρ is between zero and one. ρ equals zero means this asset does not have the inflation hedging ability, and ρ equals one means this asset has a perfect hedging ability. An asset has more hedging ability when the absolute value of ρ is higher (Spierdijk & Umar, 2013).

We can calculate the sample correlation coefficient between two variables easily. However, this is not enough to test our hypotheses. We need to determine if this correlation is statistically significant. In other words, we should perform a hypothesis test to decide whether the linear relationship in the sample data is strong enough to model the relationship in the population(Pearson, 1932).

5.5.1 T-test for correlation

The first step to performing a correlation t-test is to state null and alternative hypotheses. For example,

Null hypothesis (H_0: $\rho = 0$): The population correlation coefficient IS NOT significantly different from zero.

Alternative hypothesis (H_1: $\rho \neq 0$): The population correlation coefficient IS significantly different from zero.

After performing statistical tests by the SPSS software, we need to decide whether to reject or not to reject the null hypotheses. There are two ways, and the results obtained from these two ways are the same.

The first way is to use the P-value. We do not reject the null hypothesis if the P-value is larger than or equal to 0.05. Because there is insufficient information to conclude that these two variables have a significant linear relationship because the correlation coefficient is not statistically different from zero (Pearson, 1932). We reject the null hypothesis if the P-value is less than 0.05. Because there is sufficient information to conclude that these two variables have a significant linear relationship because the correlation coefficient is not statistically different from zero (Pearson, 1932).

The second way is to use critical value, it defines the upper and lower bounds of a confidence interval. We will construct a 95% confidence interval, which means we are 95% confident that the population parameter is in this interval. If zero is not in this interval, then the hedge measure is significantly different from zero at the 5% significance. It means this asset has a significant hedging ability (Spierdijk & Umar, 2013).

5.5.2 Null Hypothesis for this study

In chapter three, four hypotheses have been formulated. However, they cannot be tested directly, and we need to develop many null hypotheses to help us test these hypotheses.

5.5.2.1 For Hypothesis One(H1) & two(H2)

Null Hypothesis I-J (H_0: $\rho = 0$): The population correlation coefficient between the return of **I** and the return of CPI is not significantly different from zero with a **J**-month investment horizon in the Netherlands.

I = GLD, SLV, PPLT.K, PALL.K, Gold Spot Price, Silver Spot Price, Platinum Spot Price, and Palladium Spot Price.

J = One, Two, Three, Four, Five, and Six.

Sample period one (P1) is used for these hypotheses.

5.5.2.2 For Hypothesis Three

As mentioned before, we also want to compare precious metals' hedging ability between the Covid and No-covid periods.

5.5.2.2.1 For covid period.

Null Hypothesis C-K (H_0: $\rho = 0$): During the covid period, the population correlation coefficient between the return of **K** and the return of CPI is not significantly different from zero with a one-month investment horizon in the Netherlands.

K = GLD, SLV, PPLT.K, PALL.K, Gold Spot Price, Silver Spot Price, Platinum Spot Price, and Palladium Spot Price.

Sample Period Two (P2) are used for these null hypotheses.

5.5.2.2.2 For no-covid period

Null Hypothesis NC-M (H_0: $\rho = 0$): During the no-covid period, the population correlation coefficient between the return of **M** and the return of CPI is not significantly different from zero, with a one-month investment horizon in the Netherlands.

M = GLD, SLV, PPLT.K, PALL.K, Gold Spot Price, Silver Spot Price, Platinum Spot Price, and Palladium Spot Price.

Sample period three (P3) is used for these null hypotheses.

5.5.2.3 For Hypothesis Four

Hypothesis Four (H4) compares the hedging ability of ETFs and the Spot price of these precious metals. We do not need to formulate any new null hypothesis for H4. All Null Hypotheses listed before will be used for Hypothesis four (Null Hypothesis I-J, Null Hypothesis C-K, Null Hypothesis NC-M).

6. RESULTS

6.1 For Hypothesis One & Two

According to Taylor (1990), Correlations below 0.35 are considered low or weak, while those between 0.36 and 0.67 are considered moderate. Correlations between 0.68 and 1.0 indicate strong or high correlations. We found that the absolute values of the correlation coefficient are low. There are 48 sample correlation coefficients, and only one of them is larger than 35%[3] (the detailed results are displayed in table 5 in the Appendices B).

There are 48 Null Hypotheses in total for H1 and H2. We only reject Null Hypothesis PALL.K - Five[4] and do not reject the other 47 Null Hypotheses. Because the P-value of Null Hypothesis PALL.K-Five months is less than 0.05, and 0 is not in the 95% confidence interval (the detailed results are displayed in table 5 in the Appendices B).

[3] In the Netherlands, the Correlation coefficient between the return of PALL.K and CPI with five-month investment horizons during period one is -38.7%.

[4] Null Hypothesis PALL.K-Five (H_0: $\rho = 0$): The population correlation coefficient between the return of PALL.K and the return of CPI is not significantly different from zero with a five-month investment horizon in the Netherlands.

Based on the results of these null hypotheses, we reject H1 and do not reject H2. We found that in the Netherlands, Gold, Silver, Platinum, and Palladium all do not have hedging ability with short-term investment horizons.

6.2 For Hypothesis Three

There are 16 null hypotheses in total for H3, and we do not reject all these null hypotheses. Because the P-value of these Null Hypotheses are all larger than 0.05, and zero lies in the 95% confidence interval (the detailed results are displayed in table 6 in the Appendices B).

Based on the results of these null hypotheses, we reject H3. Whether the covid period or no-covid period, these four precious metals do not have hedging ability with one-month investment horizons in the Netherlands.

6.3 For Hypothesis Four

Based on the results of these null hypotheses, we reject H4. Both ETFs and Spot Price of precious metals do not have hedging ability with short-term investment horizons in the Netherlands.

7. CONCLUSIONS

In the Netherlands, Precious metals (gold, silver, platinum, and palladium) are not a good hedge against inflation with short-term investment horizons. The performance of ETFs and Spot prices of these precious metals are the same, and the ability of these precious metals during the covid and no-covid periods are also the same. In the Netherlands, Precious metals with short-term investment do not have hedging ability no matter the period (covid or no-covid) and price type (ETFs or Spot Price).

The limitation of this paper is that the sample size is relatively small. According to Pearson (1932), the correlation t-test depends on the sample size, and the estimation is more reliable and the confidence interval is more narrow when the sample size is larger.

Another limitation is that we only focus on the short-term investment horizons. Many Dutch investors may also be very interested in the hedging ability of these precious metals with long investment horizons (Spierdijk & Umar, 2013). We recommend that future studies investigate the long-term investment horizons through the VAR model of these precious metals in the Netherlands.

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9. APPENDICES A

9.1 The Fisher Coefficient

According to the Fisher hypothesis(Fisher, 1930), an asset's expected nominal return equals the sum of its expected real return and expected inflation rate for the same period (see equation 10).

(10) $E\left[R_{r,t}^{(k)}\right] = E\left[r_{r,t}^{(k)}\right] + E\left[\pi_t^{(k)}\right]$

Fama and Schwert (1977) developed a tool to test the inflation hedging ability of different assets based on the Fisher hypothesis. They use a regression model to find the relationship between an asset's nominal return and the expected part of inflation. Fama and Schwert (1977) argued that inflation consists of two parts, the first is the expected part, and the second is the unexpected part (also called the inflation risk premium).

(11) The regression model: $R_{r,t}^{(k)} = \mu + \beta * E\left[\pi_t^{(k)}\right] + \varepsilon$

$R_{r,t}^{(k)}$: The nominal return of this risky asset from t to t + k.

$E\left[\pi_t^{(k)}\right]$: The expected part of the inflation from t to t + k.

β : Regression coefficient.

μ : The intercept.

ε : An error term, the mean is 0, and the variance is σ^2.

They also want to know how an asset's nominal returns relate to the unexpected part of the inflation, so they expand the regression model into equation 12 (Fama & Schwert, 1977).

(12) $R_{r,t}^{(k)} = \mu + \beta_1 * E\left[\pi_t^{(k)}\right] + \beta_2 * (\pi_t^{(k)} - E\left[\pi_t^{(k)}\right]) + \varepsilon$

β_1 : Regression coefficient 1

β_2 : Regression coefficient 2

$\pi_t^{(k)} - E\left[\pi_t^{(k)}\right]$: The unexpected part of the inflation

This regression model is further developed in later research(Beckmann & Czudaj, 2013; Boudoukh & Richardson, 1993; Jaffe & Mandelker, 1976). The improved model is easier to use because the data it requires is ex-post (see equation 13). To assess an asset's hedging ability, we only need to know an asset's realized nominal returns and the realized inflation rates.

(13) $R_{r,t}^{(k)} = \mu + \beta\pi_t^{(k)} + \varepsilon$

We determine the hedging ability of this asset from the value of β. According to Spierdijk and Umar (2013), the asset is a perverse hedge for $\beta < 0$, a partial hedge for $0 < \beta < 1$, and a complete hedge for $\beta \geq 1$.

9.2 The Hedging Demand

Schotman and Schweitzer (2000) derived the demand for risky assets in a simple mean-variance framework to evaluate the hedge potential. They build a portfolio where a $w_t^{(k)}$ fraction is invested in risky assets and 1- $w_t^{(k)}$is invested in nominally risk-free bonds. γ means the level of the investors' risk-aversion, the value is small if an investor hates risks, and the value is significant if an investor is willing to take high risks.

The goal of a rational investor is to get a greater return with less risk. In other words, every rational investor wants to have a mean-variance optimal portfolio. The γ is fixed, and the investor need to find an optimal $w_t^{(k)}$ to achieve this goal by maximizing the equation 14.

(14) $E\left[r_{p,t}^{(k)}\right] - \dfrac{\mathrm{var}\left[r_{p,t}^{(k)}\right]}{2\gamma}$

Where:

(15) $r_{p,t}^{(k)} = w_t^{(k)} * \left(R_{r,t}^{(k)} - \pi_t^{(k)}\right) + \left(1 - w_t^{(k)}\right) * \left(R_{b,t}^{(k)} - \pi_t^{(k)}\right)$

According to Schotman and Schweitzer (2000), we can use the equation 16 to calculate the optimal $w_t^{(k)}$ for an investor with risk-aversion level at γ.

(16) $w_t^{(k)} = \gamma * \underbrace{\dfrac{E\left[r_{r,t}^{(k)} - r_{b,t}^{(k)}\right]}{\mathrm{Var}[R_{r,t}^{(k)}]}}_{\text{speculative demand}} + \underbrace{\dfrac{\mathrm{Cov}[R_{r,t}^{(k)}, \pi_t^{(k)}]}{\mathrm{Var}[R_{r,t}^{(k)}]}}_{\text{inflation-hedging demand}}$

Bodie (1982) argued that people invest in risky assets because of two needs. The first is speculative demand, and it reflects the demand for the asset that results from the real risk premium on the asset. The amount of this part is dependent on the risk-aversion level of the investor. For example, if an investor is unwilling to take any risks, this part equals zero. The second is hedging demand, and it reflects the demand for the asset that arises from its covariance with inflation. It is independent of the investor's risk-aversion level. Every investor must take the same amount if they want to form the global minimum variance (GMV) portfolio.

Schotman and Schweitzer (2000) use the inflation-hedging demand in the equation to examine the hedging ability of an asset. The inflation-hedging demand, denoted by $\boldsymbol{\Delta}_t^{(k)}$, is a ratio of the covariance of the real return of this asset and the inflation rate from time t to time t + k to the variance of the nominal return of this asset from time t to t + k (see equation 17). According to (Spierdijk & Umar, 2013), The higher the ratio, the stronger the asset as an inflation hedging instrument.

$$(17)\ \Delta_t^{(k)} = \frac{\mathrm{Cov}[R_{r,t}^{(k)}, \pi_t^{(k)}]}{\mathrm{Var}[R_{r,t}^{(k)}]}$$

9.3 The Hedge Ratio and Cost of Hedging

Bodie (1976) introduced The Hedge Ratio(S) and The Cost of Hedging(C). The Hedge Ratio(S) is calculated in three steps. The first step is to create a risk-free portfolio, and this portfolio only consists of nominal riskless bonds. The second step is to add a risky asset we want to test to this risk-free portfolio to form a GMV portfolio. The third step is to do the calculation to compare these two portfolios. The variance of the risk-free portfolio's real return is total because of the inflation risk, therefore, Bodie (1982) indicated that we could use the differences between the variance of these two portfolios' real return to refer to the hedging ability of the risky asset we add. For example, If the real return variance of the GMV portfolio is smaller than the risk-free portfolio's, it means that the risk of the GMV portfolio is less than the nominal risk-free portfolio, in other word, the risky asset we add can hedge some inflation risk.

$$(18)\ S = \frac{\text{The variance of k-period real return of the GMV portfolio}}{\text{The variance of k-period real return of the nominally risk free bond}}$$

The hedge ratio (see equation 18) is a ratio of the variance of the real return of the global minimum variance (GMV) portfolio to the variance of the real return of the risk-free portfolio. According to Spierdijk and Umar (2013), an investment has better hedging ability if the value of this ratio is lower.

$$(19)\ C = E\left[r_{n,t}^{(k)}\right] - E\left[r_{G,t}^{(k)}\right]$$

$E[r_{n,t}^{(k)}]$: Expected k-period real return on the nominally risk free bond

$E[r_{G,t}^{(k)}]$: Expected k-period real return on the GMV portfolio

The cost of hedging equals the expected real return of the GMV portfolio minus the expected real return on the global minimum variance (GMV) portfolio (see equation 19). The asset has a better hedging ability if the cost is lower. For example, the expected return of the risk-free portfolio is 10 euro, the expected return of the GMW portfolio is 9 euro. It means investors need to spend 1 euro to get the hedging ability. We need to consider the cost when choosing an asset, for example asset A and asset B have same hedging ability, Asset A is better than Asset B if the cost of hedging of asset A is lower.

10. APPENDICES B

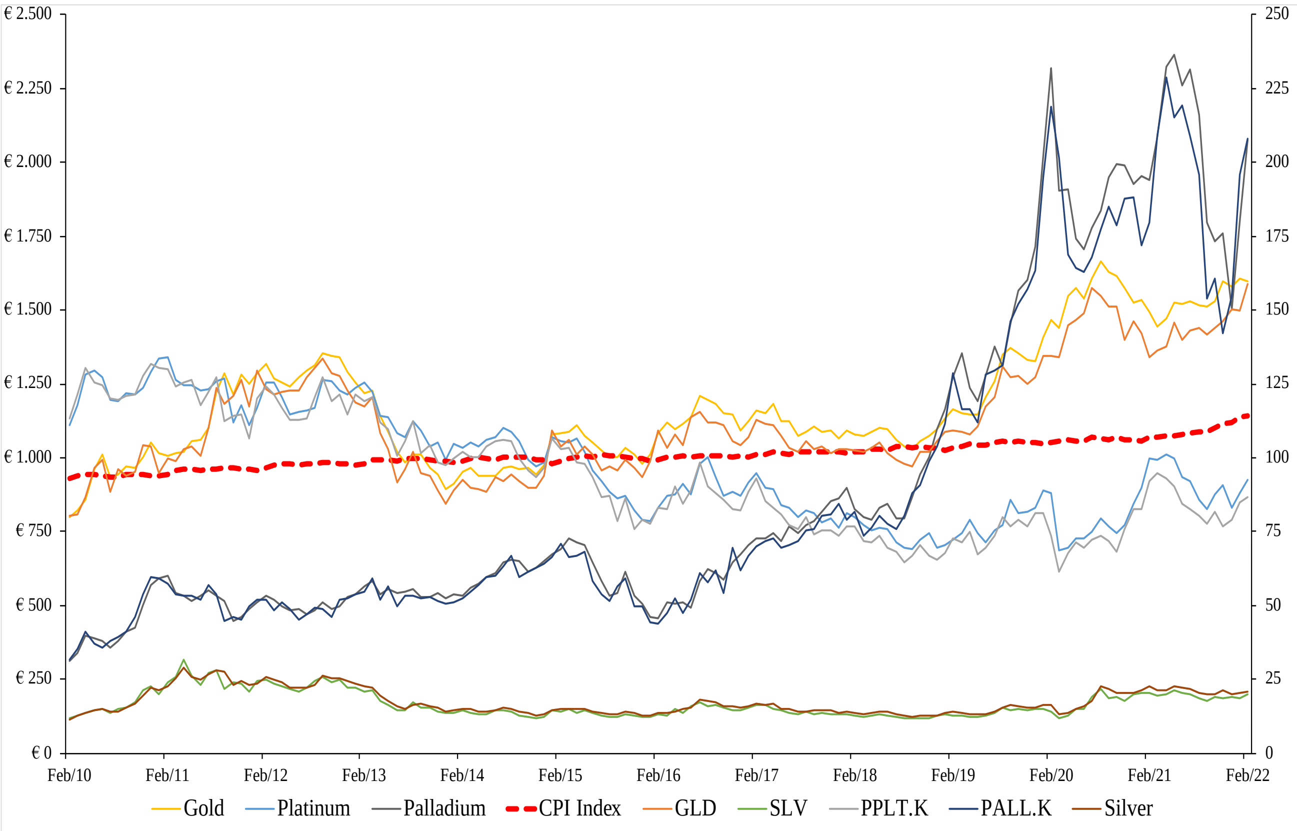

Figure 1. The change in prices from 2010.3 to 2022.2

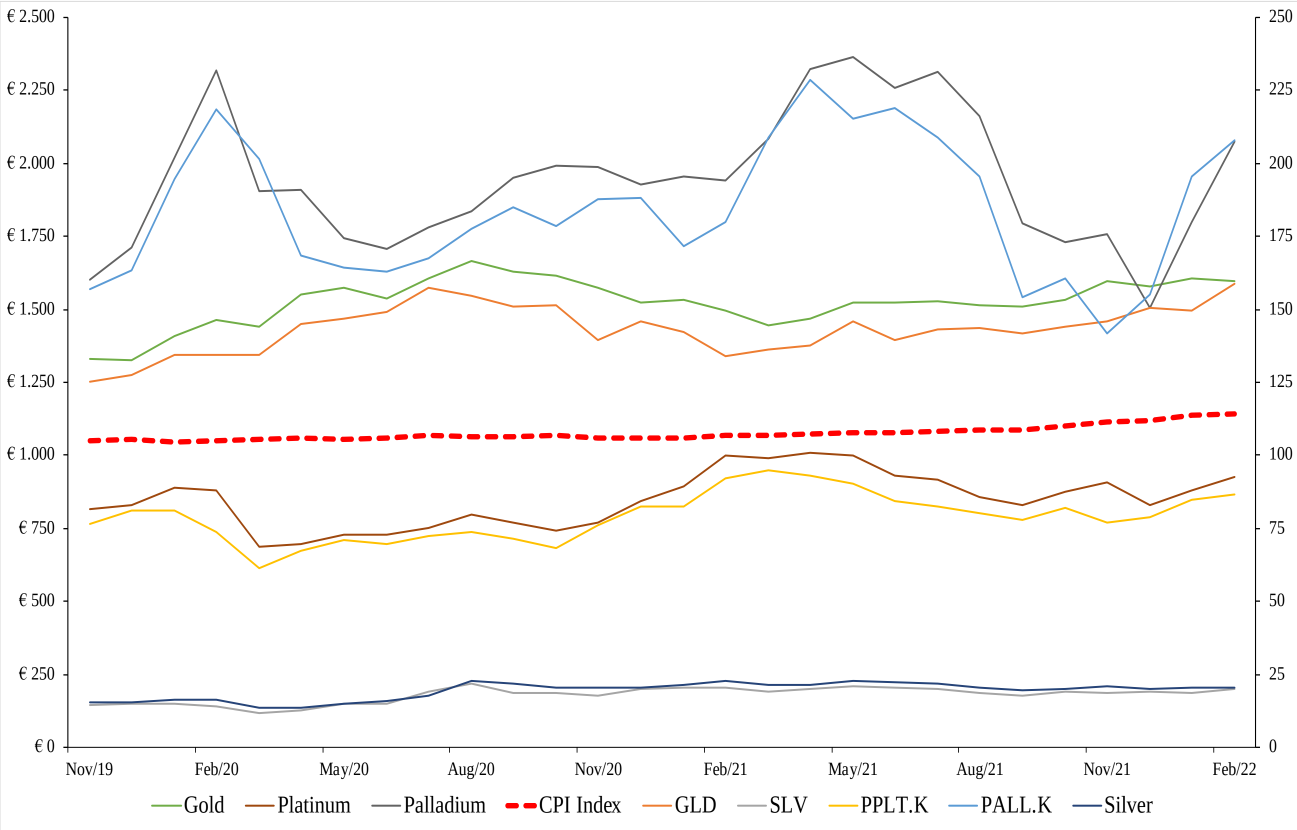

Figure 2. The change in prices from 2019.12 to 2022.2

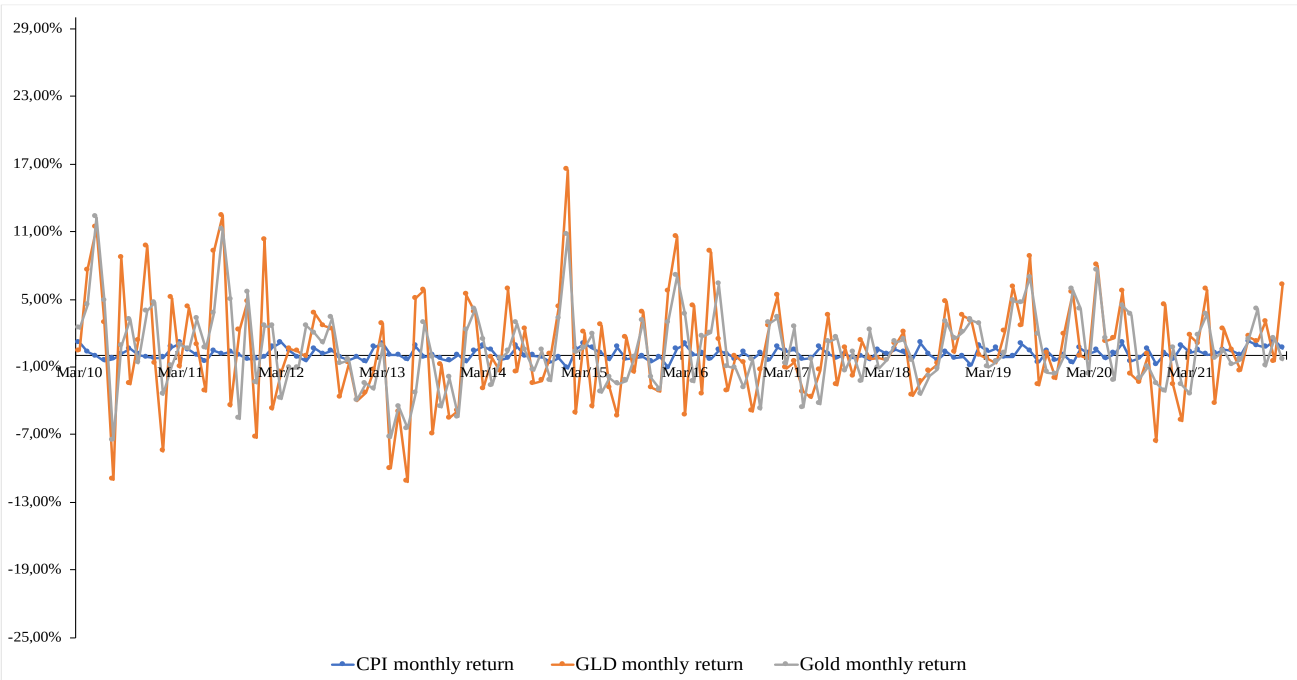

Figure. 3. The monthly return of Gold Spot price and GLD from 2010.3 to 2022.2

Figure 4. The monthly return of Silver Spot price and SLV from 2010.3 to 2022.2

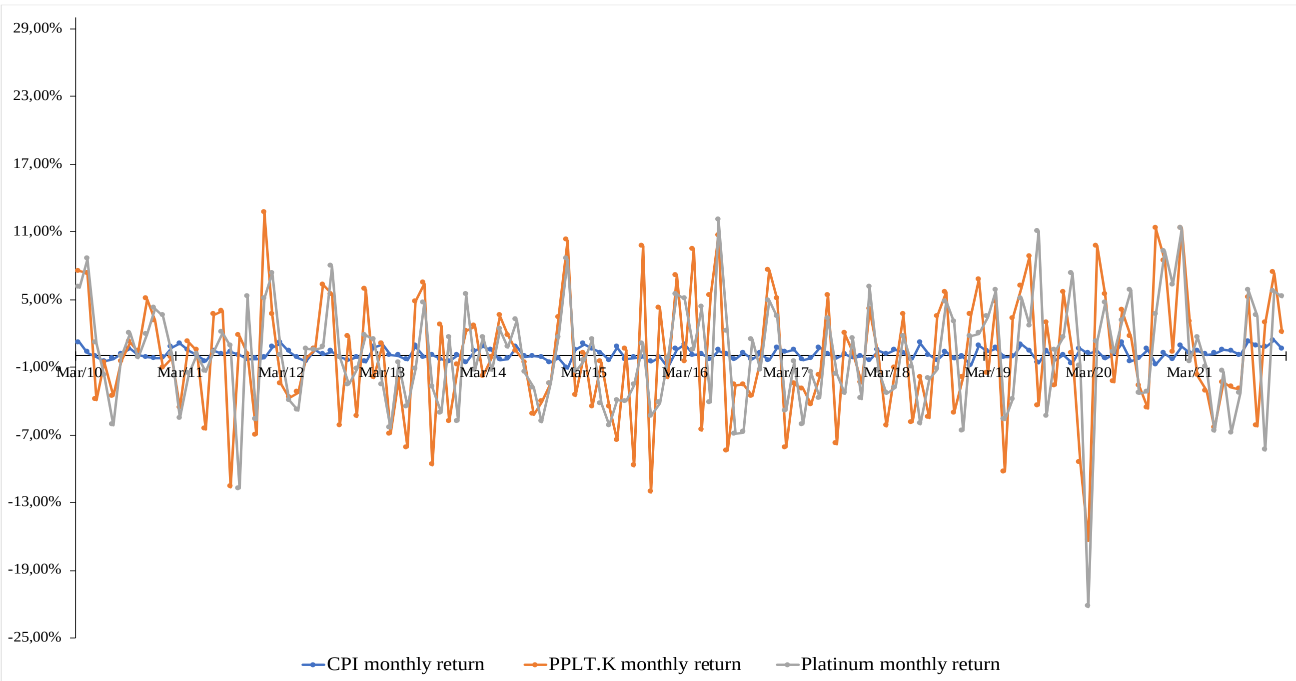

Figure 5. The monthly return of Platinum Spot price and PPLT.K from 2010.3 to 2022.2

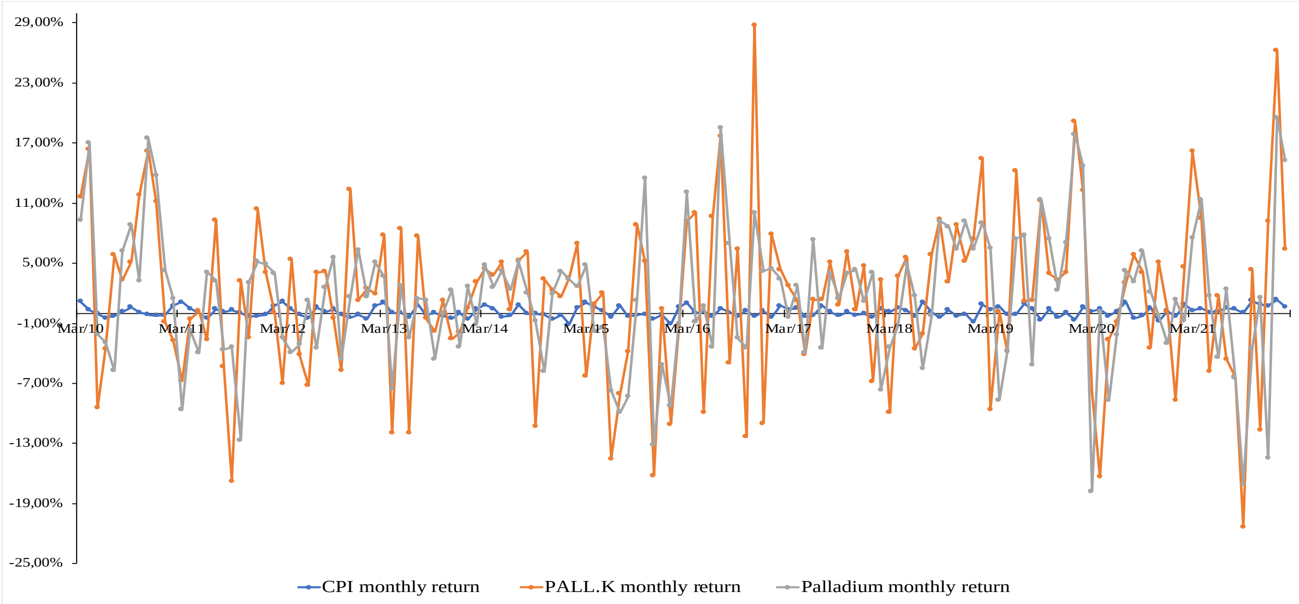

Figure 6. The monthly return of Palladium Spot price and PALL.K from 2010.3 to 2022.2

Table 3. Descriptive statistics for Period One(P1)

	Sample size	Minimum	Maximum	Mean	Standard Deviation
CPI	144	-1.1%	1.4%	0.15%	0.51%
Gold Spot Price	144	-7.5%	12.3%	0.54%	3.40%
GLD	144	-11.1%	16.5%	0.58%	4.63%
Silver Spot Price	144	-18.1%	27.9%	0.60%	6.44%
SLV	144	-23.2%	27.0%	0.73%	8.56%
Platinum Spot Price	144	-22.2%	12.0%	-0.01%	4.77%
PPLT.K	144	-16.3%	12.7%	-0.04%	5.42%
Palladium Spot Price	144	-17.7%	19.5%	1.56%	6.81%
PALL.K	144	-21.3%	28.7%	1.64%	8.17%

Table 4. Descriptive statistics for Period Two (P2) and Period Three (P3)

		Covid period (P2: 2019.12-2022.2)				No-Covid Period (P3: 2017.9-2019.11)			
	Sample Size	Min (%)	Max (%)	Mean (%)	Standard Deviation (%)	Min (%)	Max (%)	Mean (%)	Standard Deviation (%)
CPI	27	- 0.8	1.4	0.3	0.5	- 0.9	1.1	0.1	0.5
Gold Spot Price	27	- 3.4	7.6	0.7	2.9	- 3.5	6.9	0.8	2.5
GLD	27	- 7.6	8.0	1.0	3.7	- 3.6	8.7	0.7	2.8
Silver Spot Price	27	- 18.1	27.9	1.4	8.0	- 5.9	9.7	0.4	4.0
SLV	27	- 16.0	27.0	1.7	9.5	- 6.4	13.6	0.2	4.7
Platinum Spot Price	27	- 22.2	11.3	0.7	6.7	- 6.7	11.0	0.1	4.4
PPLT.K	27	- 16.3	11.3	0.7	6.5	- 10.3	8.8	- 0.1	4.9
Palladium Spot Price	27	- 17.8	19.5	1.4	9.6	- 8.7	11.4	2.9	5.7
PALL.K	27	- 21.3	26.2	1.6	10.5	- 9.8	15.4	3.0	6.3

Table 5. t-test result of Period One (P1)

Horizons (P1)		Gold Spot Price & CPI	GLD & CPI	Silver Spot Price & CPI	SLV & CPI	Platinum Spot Price & CPI	PPLT.K & CPI	Palladium Spot Price & CPI	PALL.K & CPI
One Month	ρ	0.034	0.029	0.088	0.093	0.063	0.099	0.047	0.063
	U	0.197	0.192	0.248	0.253	0.225	0.258	0.209	0.224
	L	-0.130	- 0.135	-0.076	- 0.071	-0.101	-0.066	-0.117	-0.101
	P-Value	0.684	0.727	0.292	0.267	0.451	0.240	0.573	0.452
Two Month	ρ	0.039	0.089	0.152	0.179	0.130	0.164	-0.013	0.050
	U	0.268	0.314	0.371	0.395	0.351	0.381	0.220	0.279
	L	-0.195	-0.146	-0.082	-0.054	-0.105	-0.071	-0.244	-0.183
	P-Value	0.747	0.459	0.202	0.179	0.275	0.170	0.916	0.674
Three Month	ρ	0.075	0.164	0.141	0.206	0.135	0.159	-0.063	0.017
	U	0.352	0.428	0.409	0.463	0.403	0.424	0.225	0.299
	L	-0.214	- 0.126	-0.149	- 0.083	-0.155	-0.131	-0.341	-0.269
	P-Value	0.612	0.265	0.338	0.161	0.362	0.279	0.670	0.910
Four Month	ρ	0.009	0.077	-0.014	0.022	-0.128	-0.078	-0.105	-0.080
	U	0.337	0.396	0.316	0.348	0.210	0.257	0.231	0.255
	L	-0.320	-0.358	-0.341	- 0.309	-0.438	-0.396	-0.419	-0.398
	P-Value	0.958	0.655	0.935	0.899	0.458	0.652	0.542	0.642
Five Month	ρ	-0.084	-0.081	-0.097	- 0.013	-0.205	-0.280	-0.292	-0.387
	U	0.299	0.301	0.287	0.362	0.182	0.104	0.090	-0.016
	L	-0.443	-0.441	-0.453	- 0.384	-0.537	-0.591	-0.600	-0.664
	P-Value	0.672	0.682	0.624	0.949	0.295	0.149	0.131	0.042*
Six Month	ρ	0.009	0.157	0.044	0.156	-0.036	0.042	-0.250	-0.196
	U	0.411	0.527	0.440	0.526	0.373	0.438	0.171	0.225
	L	-0.396	-0.263	-0.366	-0.264	-0.433	-0.367	-0.593	-0.556
	P-Value	0.968	0.462	0.838	0.468	0.867	0.844	0.240	0.358

Table 6. T-test result of Period Two(P2) & Period Three(P3)

		Gold Spot Price & CPI	ETF GLD & CPI	Silver spot price & CPI	SLV & CPI	Platinum spot price & CPI	PPLT.K & CPI	Palladium spot Price & CPI	PALL.K & CPI
Covid Period (P2)	ρ	0.080	0.251	-0.113	0.132	0.009	0.027	0.089	0.116
	U	0.446	0.576	0.279	0.488	0.388	0.403	0.453	0.475
	L	-0.310	-0.143	-0.472	-0.261	-0.372	-0.357	-0.302	-0.276
	P-Value	0.693	0.208	0.576	0.510	0.965	0.893	0.660	0.565
No-Covid Period (P3)	ρ	-0.034	0.136	-0.120	0.212	-0.109	0.358	-0.338	-0.123
	U	0.350	0.491	0.273	0.548	0.283	0.650	0.048	0.269
	L	-0.409	-0.257	-0.478	-0.183	-0.469	-0.025	-0.636	-0.481
	P-Value	0.866	0.498	0.553	0.288	0.590	0.067	0.085	0.540