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Piotr Wilczek https://orcid.org/0009-0007-0409-6766
Krakow University of Economics, Institute of Finance, Krakow, Poland,
s221235@student.uek.krakow.pl

The Effectiveness of Precious Metals as a Long-Term Investment in the Polish Context

Abstract: Precious metals have long served as a safe haven for investors, protecting capital value during periods of economic uncertainty, inflation, and political turbulence. Assets such as gold, silver, and platinum demonstrate relatively low correlation with traditional financial instruments, which makes them attractive tools for portfolio diversification. In the context of the Polish market, characterised by its relatively young capital market and regulatory instability, an analysis of the long-term effectiveness of investments in precious metals becomes particularly significant.

The aim of this study is to evaluate the effectiveness of precious metals as long-term investment instruments, with particular emphasis on the specificity of the Polish market. The analysis seeks to determine

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whether the inclusion of precious metals in the portfolio of a domestic investor can serve as an effective hedge against capital depreciation or enhance overall portfolio returns.

The study employs daily closing prices of four selected precious metals: gold, silver, platinum, and palladium, compared against the performance of the WIG20 and mWIG40 indices, as well as 10-year government bonds. Based on the collected data, an assessment of individual assets was conducted, including rates of return, risk, and performance indicators such as the Sharpe ratio, Jensen's alpha, the Treynor ratio, and the regret levels. Furthermore, portfolio optimisation was carried out, identifying both the minimum variance portfolio (MVP) and portfolios maximising returns for investors with specified levels of risk aversion.

The results suggest that precious metals, particularly gold and silver, represent justified additions to an investment portfolio. Both assets exhibited higher returns than other instruments during the examined period, with gold also demonstrating the lowest risk aside from government bonds. Additionally, the low correlation of precious metals with stock indices, negative in the case of gold, indicates that these assets may serve as a valuable alternative to traditional instruments during economic downturns while simultaneously enhancing portfolio stability.

Keywords: precious metals, long-term investments, portfolio theory, Polish market

JEL: C58, C61, G10, G11

1. Introduction

In the context of a dynamically changing and increasingly uncertain economic reality, investors are in constant search of stable alternatives to traditional financial instruments. Among the most frequently chosen forms of capital protection are precious metals, which for thousands of years have served both as a medium of exchange and a store of value. In particular, gold and silver, owing to their wide range of applications as well as their cultural significance, are widely recognised among the safest assets during periods of recession and heightened volatility in financial markets. Despite being only a handful of elements, they are crucial to the functioning of numerous sectors of the global economy. Gold had already been highly valued in ancient times due to its beauty and versatility. The Egyptians regarded gold as the symbol of the sun god Ra (Grimwade, 2009:11), one of the most significant deities in the Egyptian pantheon, which testifies to the exceptional position of this metal. Moreover, the ancient inhabitants of Egypt mastered the methods of working with gold. Thanks to its malleability, they were able to create not only decorations such as sarcophagi or jewellery but also practical, everyday objects. They even developed the production of gold wire and foil, which enabled gilding instead of casting objects entirely from pure gold (James, 1972:38). Not all applications of this royal metal were discovered by ancient civilisations. In today's electrified

world, gold is omnipresent and constitutes a fundamental component in the manufacturing of many electronic devices such as computers and mobile phones, which require small but essential amounts of gold. It can also be said that gold directly contributes to preserving human health and saving lives, as it is widely used in dentistry and in various medical tests, such as those for salmonella or HIV (Mennica Polska, 2024).

Silver has an equally long and rich history as gold. Its utilisation in industry and trade over the centuries elevated many civilisations to the heights of their power. The Greek poleis, which dominated its extraction as early as 1200 BC, Rome, which developed extensive mining operations on the Iberian Peninsula, and finally the Spanish Empire, whose colonies at one point were responsible for 85% of the world's silver output (The Silver Institute, 2020). The range of uses for silver is exceptionally wide, and due to its relatively lower price compared to gold, it can be found in almost every electronic device. The majority of switches in televisions, microwave ovens, smartphones, and keyboards are manufactured using silver. Until recently, traditional photography was also a major area of application for this metal, though it has been marginalised by the advance of digitisation. Just like gold, silver is employed in medicine, where its antibacterial properties provide protection for patients (Bugla-Płoskońska, Leszkiewicz, 2007:115).

Platinum and palladium are also members of the group of precious metals, which, despite being discovered relatively late, have played a significant role in the development of modern civilisation. Platinum, arguably the third most recognisable precious metal after gold and silver, was for a long time treated merely as an impurity of gold. Its name 'platina,' meaning 'little silver,' reflected this dismissive approach. It was not until the 18th century that it began to be studied more thoroughly in Europe, although evidence suggests that indigenous peoples of South America had already been using it much earlier (McDonald, Hunt, 1982:35–37). From then on, its importance grew steadily, especially in industry. Today, platinum is used not only in jewellery and watchmaking but primarily in automotive catalytic converters, which are responsible for reducing harmful emissions. The automotive sector alone consumes nearly half of global platinum production. Furthermore, platinum is a highly valued catalyst in the chemical industry, being employed in the production of nitric acid, silicon, and benzene, as well as in improving the efficiency of fuel cells. In electronics, it is applied in the production of hard drives, thermocouples, optical fibres, and LCD displays, while in medicine it serves in pacemakers, dental fillings, and anticancer drugs (Royal Society of Chemistry, 2025).

A close relative of platinum is palladium, discovered at the beginning of the 19th century by William Hyde Wollaston during his work on refining platinum (McDonald, Hunt, 1982:153–154). Both metals share numerous characteristics and uses. Palladium, like platinum, is a fundamental component of modern automotive catalytic converters and plays an important role in electronics. Particularly notable are ceramic capacitors made with its use, as well as its application in hydrogenation and dehydrogenation processes in industrial chemistry (Royal Society of Chemistry, 2024). One cannot overlook the use of all precious metals in jewellery, which accounts for anywhere from a dozen percent, as in the case of palladium, to more than fifty percent of the total utilisation of a given metal (Grimwade, 2009:13).

The present article constitutes a continuation of the author's earlier work, in which the efficiency of investments in precious metals was analysed over the course of a decade and compared with American financial assets. In this study, an attempt was made to examine the effectiveness of investing in gold and silver within the conditions of the Polish capital market. The performance of these metals was compared with the results achieved during the same period by the domestic stock indices WIG20 and mWIG40, as well as ten-year government bonds. Against this background, the aim of the article is to determine whether, in the specific context of the Polish economy, precious metals can be considered a justified addition to a long-term investment portfolio, one that could provide either a higher rate of return or lower risk compared to a portfolio without exposure to metal markets.

To achieve the research objective, data covering the years 2015–2025 were employed. The calculations were based on the yields of government bonds and daily closing prices of the WIG20 and mWIG40 indices, as well as on selected four precious metals, namely gold, silver, platinum, and palladium.

2. Literature Review

The present study is based both on the author's earlier considerations and on several works carried out by other researchers. The primary inspiration was the research conducted by Magdalena Walczak (2012), which analysed the performance of precious metals alongside the WIG20 and WIG indices. The period under investigation covered the years 2008–2011. Data concerning precious metals were presented on the basis of the second LBM fixing at the end of each month, and subsequently, the collected values were adjusted to a larger number of observations in the case of stock indices.

With the data prepared in this way, the author calculated both daily rates of return and levels of standard deviations. In the following step, a correlation matrix of the previously mentioned assets was constructed. Subsequently, four different investment portfolios were created, each supplementing the WIG20 index with selected precious metals, in proportions dictated by Markowitz's portfolio theory. This approach enabled the author to obtain minimum-risk portfolios with differing rates of return.

On the basis of these operations, the author reached the conclusion that each of the minimum-risk portfolios was characterised by a standard deviation lower than that of a portfolio composed solely of traditional instruments. Furthermore, all the portfolios achieved higher rates of return. This leads to the conclusion that under Polish conditions, assuming returns remain close to those observed during the studied years, there exists an opportunity for diversification and improvement of market portfolio efficiency through alternative investments in the form of precious metals (Walczak, 2012:393).

Another important contribution to the international literature on precious metals is the study by Hillier, Draper, and Faff, which analysed the role of gold, silver, and platinum in financial markets using daily data from the period 1976–2004. The authors examined the relationships between precious metal returns and stock market indices, including the S&P 500 and the MSCI

EAFE index. Their findings indicate that the returns of precious metals exhibit very low or close-to-zero correlations with equity market returns, which suggests that these assets may provide meaningful diversification benefits within broadly constructed investment portfolios. Furthermore, the results demonstrate that precious metals may also serve a hedging function during periods of increased market volatility. In particular, the study shows that the negative relationship between precious metals and equity markets tends to strengthen during turbulent market conditions, which enhances their diversification value. Portfolio simulations conducted by the authors also revealed that including precious metals, especially gold, in equity portfolios improved their efficiency and risk-adjusted performance, indicating that these assets may represent a valuable long-term component of diversified investment strategies (Hillier, Draper, Faff, 2006).

The next study was conducted by Anna Kasprzak-Czelej (2018), who sought to determine whether, from the perspective of an investor holding assets denominated in PLN, precious metals could be treated as a distinct asset class. In order to address this question, she collected data from the period January 2006 – August 2016. The basis for calculations included monthly prices of gold, silver, and platinum expressed in USD, drawn from the World Bank database, as well as monthly prices of palladium calculated in USD from daily afternoon London market prices, provided by the London Platinum & Palladium database. Additionally, the author prepared data concerning the real estate market, commodities, the S&P index, and bonds for further calculations.

What is particularly noteworthy in the context of the present study is the examination of correlations between precious metals and the WIG and S&P 500 indices. For assets denominated in PLN, the correlation of all precious metals with the Polish index proved to be negative, whereas with the S&P index it was positive. Furthermore, if the assets were denominated in USD, a negative correlation was observed only in the gold/WIG and gold/S&P 500 pairs, while all other cases displayed correlations not only greater than zero but also higher than their analogous PLN-denominated pairs. Such findings may suggest that precious metals possess risk-diversifying potential, particularly in the Polish context, which was under scrutiny in this study.

The final, though by no means less important, study referenced in this work is that of Urszula Gierałtowska (2013). The author analysed two precious metals, silver and gold, as well as the possibility of investing in them through funds. The results of empirical research indicate that returns from investments in silver and gold exhibit a strong mutual dependence, while at the same time their correlation with traditional financial assets remains low or negative. This implies that including precious metals in an investment portfolio may yield benefits in the form of risk diversification, a conclusion further supported by correlation analyses involving the returns of major stock indices and currency exchange rates. Moreover, the author highlights the growing importance of indirect instruments such as ETFs, structured certificates, or domestic investment funds specialising in precious metals. Such solutions minimise logistical and cost-related barriers associated with physical metal trading, while simultaneously offering investors liquidity and comparable rates of return.

In the final part of the study, investment portfolios were constructed and compared. In addition to a classical portfolio composed of shares of companies included in the WIG20 index, portfolios incorporating components of gold, silver and participation units in the Investor Gold Open Fund were created. Subsequently, using the model developed by H. Markowitz (1952), asset allocation proportions were calculated, identifying combinations characterised by the lowest standard deviation. The inclusion of exposure to the precious metals market in the portfolios resulted in higher rates of return and reduced potential risk.

The author concludes that incorporating alternative instruments into an investment portfolio increases its resilience to market fluctuations. In accordance with Markowitz's theory, an allocation of 17–40% ensures effective diversification; however, even a smaller level of involvement in such assets reduces the risk of declines in portfolio value (Gierałtowska, 2013:99).

3. Methodology

The empirical analyses conducted in this study were primarily based on the tools of Markowitz's portfolio theory (Markowitz, 1952). This method makes it possible to determine such proportions of individual assets that construct a portfolio with the lowest possible level of risk for a given rate of return, or alternatively, a portfolio that ensures the highest return for a defined level of risk, where risk is measured by standard deviation. In addition, a range of other indicators was calculated, both for individual assets and for the portfolio as a whole. To determine these, the risk-free rate was also employed, defined as the daily yield of 10-year government bonds during the period 1.01.2015–1.01.2025, obtained from the archival interest rate tables published by the Polish Ministry of Finance.

In order to assess investment attractiveness, Sharpe, Treynor, and Jensen indicators were also used. The first of these illustrates the relationship between the risk premium and the level of risk; the second adds to this calculation the aspect of volatility relative to the market, captured by the beta coefficient. Jensen's alpha, on the other hand, verifies whether the return level of a given asset was higher or lower than the one predicted by the CAPM model. The index representing the market in this study was the mWIG40 index. Typically, the main stock exchange index is regarded as the measure of market condition; however, during the analysed period, the performance of the WIG20 was so weak that it disqualified it as a credible benchmark.

The indicators can be expressed by the following formulas presented below (Jensen, 1968; Sharpe, 1994; Tonks, 2006):

$$S = \frac{\mathrm{r}_i - r_f}{\sigma_i}, \tag{1}$$

where: r_i – rate of return from asset *i*, r_f – risk-free rate, σ_i – standard deviation of asset *i*,

$$T = \frac{\mathrm{r}_i - r_f}{\beta_i}, \tag{2}$$

where: r_i – rate of return from asset *i*, r_f – risk-free rate, β_i – Beta of asset *i*,

$$\alpha = \mathrm{r_i} - [\mathrm{r_f} + \beta_\mathrm{i}(\mathrm{r_m} - \mathrm{r_f})], \tag{3}$$

where: r_i – rate of return from asset *i*, r_f – risk-free rate, r_m – market return, β_i – Beta of asset *i*.

The final factors incorporated into the conducted analysis are the utility and regret indicators. Utility is treated as a measure of how well an investment portfolio aligns with the level of risk that an investor is willing to accept. To determine it, the Theta parameter was applied, the value of which varied depending on the degree of risk aversion, specifically: 2, 3.5, and 5, where the highest value (5) represented the strongest reluctance of the investor to undertake risky decisions. The utility indicator is calculated according to the following formula (Rao, 2020):

$$U = r_p - \frac{\theta}{2} * {\sigma_p}^2, \tag{4}$$

where: *r* – rate of return on a portfolio, σ_p – standard deviation of a portfolio, θ – Theta.

The regret indicator, by contrast, is a relatively new tool in the field of portfolio analysis, proposed in research by Baule, Korn and Kuntz (2018). This measure makes it possible to account for the emotional aspect of investing, namely the regret an investor may experience for not having invested in the asset that delivered the best performance. On this basis, it becomes possible to determine a portfolio that will be acceptable to the investor. In the present study, the regret indicator was calculated according to the formula presented below (Baule, Korn, Kuntz, 2018):

$$R_p = \sqrt{(\mathrm{W}*\mathrm{R}) * W^T}, \tag{5}$$

where: *W* – matrix of portfolio weights, *R* – asset regret matrix.

The data used for all calculations were obtained from the website https://stooq.pl/. These are historical daily closing prices from the past 10 years. The exact period under examination begins on 1.01.2015 and ends on 1.01.2025. The analysed assets are as follows:

1) gold quoted in Polish zloty per troy ounce (XAUPLN);
2) silver quoted in Polish zloty per troy ounce (XAGPLN);
3) platinum quoted in Polish zloty per troy ounce (XPTPLN);
4) palladium quoted in Polish zloty per troy ounce (XPDPLN);
5) WIG20 index (WIG20);
6) mWIG40 (MWIG40);
7) 10-year Polish government bonds issued on 1.01.2015.

The way in which the prices of the following assets evolved over the analysed ten-year period is illustrated by the charts.

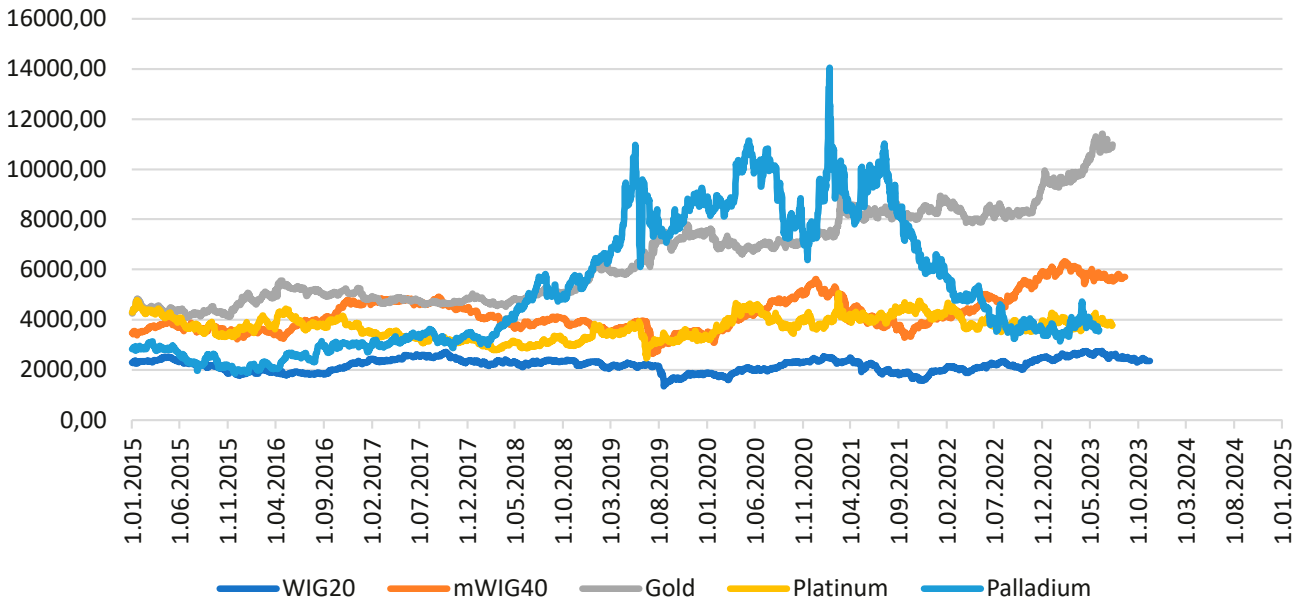

Chart 1. Prices of selected assets during 2015–2025
Source: own calculations.

Chart 2. Prices of silver during 2015–2025
Source: own calculations.

The first chart presents a comparison of stock market indices (WIG20, mWIG40) and precious metal prices (gold, platinum, palladium) over the years 2015–2025. It is evident that precious metals, particularly palladium and gold, exhibit significantly higher growth dynamics than stock indices. The pandemic period (2020–2021) brought pronounced spikes in metal prices, highlighting their role as safe-haven assets during times of economic uncertainty. However, not all metals performed equally well; palladium, after very large gains, returned to levels

similar to those before the pandemic, while platinum is cheaper than at the start of the studied period. Stock indices, especially the WIG20, experienced much lower growth than gold or palladium, which will become more apparent in later sections of the study.

The second chart shows the price trends of silver over the same period. Its growth dynamics, although lower than those of palladium, display a similar tendency to rise during crisis periods. Silver prices remained in the range of fifty to seventy PLN per troy ounce for a long time; however, from 2020 onwards, a significant breakout occurred, moving to a higher price level with fluctuations reaching up to 140 PLN per troy ounce. It is noteworthy that, like gold, silver prices did not fall following the initial supply shock triggered by the pandemic.

The research hypothesis for the conducted study posited that exposure to precious metals within a portfolio composed of traditional instruments, namely government bonds and the WIG20 and mWIG40 indices, would have a positive impact on both the achieved rate of return and the level of risk.

Based on the collected data and the applied research methods, it was possible to carry out analyses that contributed to achieving the stated objective of the study. The following section presents the results obtained from the calculations performed.

4. Results

The introduction to further considerations and analyses involved determining all necessary indicators related to individual assets. The results of these calculations are presented in Table 1 below.

Table 1. Selected indicators for bonds, WIG20, mWIG40, gold, silver, platinum, and palladium (%)

	Bonds	WIG20	mWIG40	Gold	Silver	Platinum	Palladium
Rate of return	5.67	– 0.52	5.78	9.81	7.76	– 1.36	2.88
Standard deviation	0.00	18.12	14.38	12.30	21.08	19.49	28.69
Beta		62.23	100.00	– 15.02	3.89	8.35	7.07
Risk-free rate	5.67	5.67	5.67	5.67	5.67	5.67	5.67
Sharpe's indicator		– 34.13	0.82	33.68	9.96	– 36.07	– 9.70
Treynor's indicator		– 9.94	0.12	– 27.57	53.88	– 84.21	– 39.34
Jensen's Alpha		– 6.19	0.12	4.14	2.10	– 7.03	– 2.78
Regret indicator	21.48	24.00	22.96	21.14	22.62	21.34	24.64

Source: own calculations.

The first aspect worth examining is the distribution of returns. Gold clearly achieved the highest return, reaching 9.81%, followed by silver at 7.76%. In third place was the stock index mWIG40 (5.78%), closely followed by ten-year government bonds with a return of 5.67%. Palladium recorded a low return of 2.88%, which, unlike WIG20 (–0.52%) and platinum (–1.36%), remained positive.

Next, considering risk measured by standard deviation, the lowest risk is associated with government bonds, which are conventionally assumed to have zero risk, reflecting their safe nature and guaranteed return. Therefore, for subsequent calculations, the bond return was treated as the annual risk-free rate. In the case of stock indices, volatility levels were higher, amounting to 18.12% for WIG20 and 14.38% for mWIG40, indicating significant exposure to market fluctuations, though still lower than for certain metals. Precious metals exhibited a wide range of risk levels. Gold proved to be the most stable in this group (12.30%), followed to a lesser extent by platinum (19.49%). Much higher risk accompanied investments in silver (21.08%) and, particularly, palladium, which recorded the highest volatility at 28.69%. It should be noted, however, that palladium's results are likely exaggerated due to the COVID-19 pandemic period included in the analysis.

As mentioned in the methodology section, the market benchmark was chosen as the mWIG40 index due to the limitations of WIG20 as a representative of the Polish economy. With this assumption in mind, gold exhibited the lowest beta coefficient (–15.02%), suggesting a potential inverse correlation with the traditional market. The next lowest betas were observed for silver (3.89%), followed by palladium (7.07%) and platinum (8.35%), indicating that all metals recorded relatively low beta values.

The Sharpe ratio examines the relationship between the achieved return and the risk undertaken; higher values are preferable. In the table, gold obtained the highest Sharpe ratio (33.68%), indicating a more favourable return–risk relationship than other assets and confirming that it was the most efficient investment during the studied period. Positive, albeit significantly lower, Sharpe values were also recorded for silver (9.96%) and mWIG40 (0.82%), indicating that investors received compensation for the risk taken, albeit to varying degrees. In contrast, assets such as platinum, WIG20, and palladium had negative Sharpe ratios, suggesting that investments in these assets were not profitable relative to the risk incurred. It should also be noted that government bonds, due to the assumed zero standard deviation, could not have a Sharpe ratio calculated.

The Treynor ratio evaluates the relationship between returns above the risk-free rate and systematic risk measured by beta. However, due to gold's negative beta, its Treynor ratio is not meaningful. Analysis shows that only silver (53.88%) and mWIG40 (0.12%) recorded positive Treynor ratios, while all other assets were below zero.

The final two indicators analysed are Jensen's alpha and the regret measure. Jensen's alpha results merely confirm the conclusions drawn from the other indicators. Gold achieved the highest alpha (4.14%), followed by silver (2.10%), with mWIG40 recording the last positive value (0.12%). All other assets had negative values. The regret measure indicates that an investor will

experience the least regret by allocating capital to gold (21.14%), followed interestingly by platinum (21.34%). The assets likely to generate the most regret for a potential investor are WIG20 (24.00%) and palladium (24.64%).

Table 2. Correlation coefficient between: WIG20, mWIG40, gold, silver, platinum, and palladium

	WIG20	mWIG40	Gold	Silver	Platinum	Palladium
WIG20	1.0000	0.7842	– 0.1226	0.0616	0.1353	0.1611
mWIG40	0.7842	1.0000	– 0.1544	0.0776	0.1705	0.2030
Gold	– 0.1226	– 0.1544	1.0000	0.7037	0.5237	0.3126
Silver	0.0616	0.0776	0.7037	1.0000	0.6083	0.3870
Platinum	0.1353	0.1705	0.5237	0.6083	1.0000	0.5189
Palladium	0.1611	0.2030	0.3126	0.3870	0.5189	1.0000

Source: own calculations.

The next aspect analysed was the correlation coefficient among the assets included in the study. Based on the results presented in the table above, it can be observed that gold (–0.1226 and –0.1544) exhibited a negative correlation with both stock indices, suggesting that it has significant potential for portfolio risk diversification. The second lowest correlation with traditional instruments during the analysed period was observed for silver (0.0616 and 0.0776); although positive, it remained relatively low. The remaining metals, platinum and palladium, recorded similar correlation values, ranging from 0.1353 to 0.2030.

Correlations among the metals themselves are relatively high, particularly between gold and silver (0.7037). The lowest correlation among metals was found between palladium and gold (0.3126) and between palladium and silver (0.3870).

This part of the study was dedicated to portfolio optimisation based on changing criteria and to assessing whether investment in precious metals would provide benefits to investors in the form of higher returns, lower standard deviation, or better alignment with investor preferences.

The first portfolio analysed was the minimum-risk portfolio. However, due to the inclusion of government bonds among the assets, the results of such a portfolio are significantly skewed, as the zero standard deviation causes the entire portfolio weight to be allocated to the bonds. Therefore, there was no basis for further analysis of this variant, since the portfolio results would be identical to those of the bonds themselves.

Table 3. Minimum-risk portfolio

Portfolio component	Portfolio weight
Bonds	100.00%
WIG20	0.00%
mWIG40	0.00%

Portfolio component	Portfolio weight		
Gold	0.00%		
Silver	0.00%		
Platinum	0.00%		
Palladium	0.00%		
Portfolio characteristics			
Rate of return	5.67%		
Standard deviation	0.00%		
Sharpe's indicator			
Theta	2	3.5	5
Utility indicator	5.67%	5.67%	5.67%
Regret indicator	21.48%		

Source: own calculations.

The next portfolio, which is of limited interest in the context of this study, was the maximum-return portfolio. Similar to the case of minimising standard deviation, in this scenario all funds were allocated to the asset with the highest return, which was gold. What is noteworthy about this portfolio, however, is that for an investor with a low level of risk aversion, it represents the optimal choice. The results of this portfolio are presented in the table below.

Table 4. Maximum-return portfolio

Portfolio component	Portfolio weight		
Bonds	0.00%		
WIG20	0.00%		
mWIG40	0.00%		
Gold	100.00%		
Silver	0.00%		
Platinum	0.00%		
Palladium	0.00%		
Portfolio characteristics			
Rate of return	9.81%		
Standard deviation	12.30%		
Sharpe's indicator	33.68%		
Theta	2	3.5	5
Utility indicator	8.30%	7.16%	6.03%
Regret indicator	21.14%		

Source: own calculations.

The first more interesting portfolio, which served as a kind of starting point for further considerations, was the equally weighted portfolio (also referred to as naive diversification). In this setup, an investor with access to seven different assets allocates an equal amount to each of them, resulting in a portfolio with equal weights across all instruments. The results of this portfolio are presented in the table below.

Table 5. Equal-weights portfolio

Portfolio component	Portfolio weight		
Bonds	14.29%		
WIG20	14.29%		
mWIG40	14.29%		
Gold	14.29%		
Silver	14.29%		
Platinum	14.29%		
Palladium	14.29%		
Portfolio characteristics			
Rate of return	4.29%		
Standard deviation	10.64%		
Sharpe's indicator	– 12.94%		
Theta	2	3.5	5
Utility indicator	3.16%	2.31%	1.46%
Regret indicator	17.09%		

Source: own calculations.

What immediately stands out when examining the results of the portfolio above is the fact that, despite its lower rate of return (4.29%) compared to most individual assets, the equal distribution of the portfolio provides the investor with a lower standard deviation than any single asset, apart from government bonds. However, this does not change the fact that such a portfolio underperformed and carried higher risk than government bonds alone. Another interesting observation, from the perspective of this study, is that this portfolio recorded the lowest level of regret among all the constructed portfolios.

Taking as the standard deviation value the one achieved through the equally weighted portfolio (10.64%), and then maximising the portfolio in terms of return, resulted in a portfolio with the outcomes presented in the table below.

Table 6. Maximum-return portfolio for a given standard deviation

Portfolio component	Portfolio weight
Bonds	1.36%
WIG20	0.00%
mWIG40	11.41%

Portfolio component	Portfolio weight		
Gold	87.22%		
Silver	0.00%		
Platinum	0.00%		
Palladium	0.00%		
Portfolio characteristics			
Rate of return	9.29%		
Standard deviation	10.64%		
Sharpe's indicator	34.08%		
Theta	2	3,5	5
Utility indicator	8.16%	7.31%	6.46%
Regret indicator	20.34%		

Source: own calculations.

The portfolio constructed in this way managed to achieve a rate of return only slightly lower, by just 0.54 percentage points, than the best-performing individual asset, which was gold. At the same time, the risk remained lower by 1.66 percentage points. Additionally, this and the next two portfolios are maximising the Sharpe ratio, representing the relationship between the achieved rate of return and the level of risk undertaken.

The last two portfolios examined maximise utility for investors with different degrees of risk aversion. The first corresponds to a medium level, while the second applies to an investor with high risk aversion. The results of these portfolios are presented in the tables below.

Table 7. Maximum-utility portfolio for Theta 3.5

Portfolio component	Portfolio weight		
Bonds	9.76%		
WIG20	0.00%		
mWIG40	10.41%		
Gold	79.82%		
Silver	0.00%		
Platinum	0.00%		
Palladium	0.00%		
Portfolio characteristics			
Rate of return	8.98%		
Standard deviation	9.74%		
Sharpe's indicator	34.08%		
Theta	2	3.5	5
Utility indicator	8.04%	7.33%	6.61%
Regret indicator	20.23%		

Source: own calculations.

It can be observed that the portfolios for investors with medium and high-risk aversion do not differ in terms of the selected instruments, either from each other or from the earlier portfolio that maximised return at a given level of standard deviation. What does change, however, is the proportional allocation of capital. As the investor's risk aversion increases, the share of the least risky asset, which are government bonds, also increases. At the same time, the exposure to gold and the mWIG40 index decreases.

Table 8. Maximum-utility portfolio for Theta 5

Portfolio component	Portfolio weight		
Bonds	36.83%		
WIG20	0.00%		
mWIG40	7.29%		
Gold	55.88%		
Silver	0.00%		
Platinum	0.00%		
Palladium	0.00%		
Portfolio characteristics			
Rate of return	7.99%		
Standard deviation	6.82%		
Sharpe's indicator	34.08%		
Theta	2	3.5	5
Utility indicator	7.52%	7.18%	6.83%
Regret indicator	20.12%		

Source: own calculations.

Interestingly, the final portfolio achieved a much lower standard deviation than all of the available instruments except government bonds (6.82%), while its rate of return (7.99%) exceeded that of the second-best individual asset, namely silver.

5. Discussion of Results

When comparing the results obtained in this study to the earlier research on precious metals, several similarities and differences can be observed. Starting with the study by Magdalena Walczak, which analysed the performance of precious metals and the WIG and WIG20 indices during 2008–2011, it is clear that in this study, precious metals likewise enabled investors to diversify part of the risk while increasing returns relative to traditional instruments. What differentiates Walczak's research from the present study is the inclusion of government

bonds and a second stock index, the mWIG40, as well as the ability to construct portfolios with a broader set of instruments. Moreover, the data collection period in this article is significantly longer, which in theory should reduce the influence of temporary trends.

When comparing correlation levels to those reported by both Walczak and Anna Kasprzak-Czelej, some differences arise. In this study, gold recorded a negative correlation (–0.1226) with the WIG20 index, whereas in Walczak's research it was positive (0.131). This discrepancy may stem from the different research periods considered. Correlations of the remaining metals with the index were also higher in Walczak's study than in the present one. Meanwhile, in Kasprzak-Czelej's study, all precious metals displayed negative correlations with the WIG index, which was not the case here. Gold being the metal with the lowest correlation to the broad stock index was also a common finding between this study and the research conducted by Hillier, Draper, and Faff. However, comparing the WIG20 with the S&P 500 is less informative than comparisons with earlier studies focusing specifically on the Polish market.

Looking again at portfolio analysis, this time the one carried out by Urszula Gierałtowska, we see that adding exposure to precious metals also increased potential investment returns and reduced overall portfolio risk. The current study confirms such findings, although both analyses used different definitions of traditional investments. In Gierałtowska's work, traditional assets consisted solely of shares from the WIG20 index, while in this article's analysis, two stock indices and government bonds were included. The latter significantly influenced portfolio outcomes by providing a risk-free rate of return.

In conclusion, the results of both previous studies and the analyses presented in this article suggest that precious metals, as seen in the studied period, can serve as a valuable long-term investment, either as a complement to, or even as a core component of, an investment portfolio. This is particularly true for gold, whose low correlation with stock indices and relatively high rate of return, when combined with government bonds, enabled the achievement of higher profitability and lower standard deviation than capital allocated to single assets.

What this study did not include, and what could be developed in future research, is an extended analysis period, which would allow for an even more robust presentation of asset performance. The years considered here encompassed the COVID-19 pandemic, which may have positively influenced the profitability of precious metals given their historically strong performance during times of economic uncertainty. The supply shock triggered by the pandemic, for example, significantly affected palladium prices, meaning its results may be distorted and could appear entirely different over another time horizon.

Furthermore, future research should consider other assets as representatives of traditional investments, since the historical performance of the selected stock indices leaves much to be desired. Additionally, upcoming analyses could incorporate costs associated with taxation of specific instruments, as well as storage or insurance expenses linked to holding precious metals.

6. Conclusions

Precious metals occupy a unique place in both human culture and finance. Their industrial and aesthetic properties have been valued for thousands of years. This study, by examining their effectiveness as long-term investments in the Polish market, only reinforces this perspective.

The analyses conducted suggest the validity of the claim that precious metals hold significant diversification potential. Gold, in particular, during the analysed period, stood out with a relatively high rate of return combined with a negative correlation to stock indices, making it an effective hedge against the decline in value of traditional assets during periods of economic downturn. Silver, if not for the dominant role of gold in the portfolio analyses, would also have been among the assets providing above-average profitability. The remaining metals, however, did not prove to be equally attractive investments.

Thus, the research hypothesis, that exposure to precious metals in a portfolio composed of traditional instruments, namely government bonds and the WIG20 and mWIG40 indices, would positively influence both the achieved rate of return and the risk level, was only partially confirmed. The partial confirmation results from the fact that palladium and platinum proved objectively less attractive investments during the studied period, and their inclusion in a portfolio would not have been beneficial.

It is important, however, to acknowledge certain limitations of the study. Firstly, the analysed period encompassed exceptional economic events, which may have disproportionately influenced precious metal prices. Secondly, the research considered only selected stock indices and government bonds, which do not represent the full spectrum of available financial instruments. Finally, tax-related and logistical costs were not accounted for, though in practice these factors could significantly alter the effectiveness of such investments.

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Efektywność metali szlachetnych jako inwestycji długoterminowej w realiach polskich

Streszczenie: Metale szlachetne od wieków pełnią funkcję bezpiecznej przystani dla inwestorów, chroniąc wartość kapitału w okresach niepewności gospodarczej, inflacji oraz zawirowań politycznych. Złoto, srebro czy platyna wykazują relatywnie niską korelację z tradycyjnymi aktywami finansowymi, co czyni je atrakcyjnymi narzędziami dywersyfikacji portfela inwestycyjnego. W polskich realiach, charakteryzujących się stosunkowo młodym rynkiem kapitałowym oraz niestabilnością regulacyjną, analiza długoterminowej efektywności inwestycji w metale szlachetne nabiera szczególnego znaczenia.

Celem artykułu jest ocena efektywności metali szlachetnych jako instrumentów inwestycyjnych w perspektywie długoterminowej, ze szczególnym uwzględnieniem specyfiki polskiego rynku. Analiza ma na celu

wskazanie, czy włączenie metali szlachetnych do portfela inwestycyjnego inwestora krajowego może stanowić skuteczne zabezpieczenie wartości kapitału lub zwiększyć zwrot z portfolio.

W badaniach wykorzystano dzienne ceny zamknięcia czterech wybranych metali szlachetnych, czyli złota, srebra, platyny i palladu, które zestawiono z wynikami indeksów WIG20, mWIG40 oraz 10-letnich obligacji skarbowych. Na podstawie zebranych danych została przeprowadzona analiza poszczególnych aktywów, gdzie zbadano ich stopy zwrotu, ryzyko, wskaźniki Sharpe'a, Jensena oraz Treynora, a także współczynnik żalu. Dodatkowo została przeprowadzona optymalizacja portfeli składających się z wymienionych aktywów, zarówno w poszukiwaniu portfela MVP, jak i takiego, który maksymalizuje zysk dla inwestora o konkretnej awersji na ryzyko.

Wyniki badań sugerują, iż metale, a konkretnie złoto i srebro, są zasadnymi propozycjami do włączenia w portfolio inwestycyjne. Zarówno złoto, jak i srebro odznaczały się w badanym okresie wyższą stopą zwrotu niż pozostałe aktywa, przy czym złoto posiadło również najniższe ryzyko, nie licząc obligacji. Dodatkowo niska korelacja metali z indeksami giełdowymi, a w przypadku złota nawet ujemna, sugeruje, iż kruszce mogą stanowić dobrą alternatywę dla klasycznych instrumentów w okresie dekoniunktury, jednocześnie zwiększając stabilność portfolio.

Słowa kluczowe: metale szlachetne, inwestycje długoterminowe, teoria portfelowa, rynek polski