GOSPODARKA SUROWCAMI MINERALNYMI – MINERAL RESOURCES MANAGEMENT

2023 Volume 39 Issue 2 Pages 125–143

DOI: 10.24425/gsm.2023.145883

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Gold mining stocks – an investor's perspective

Introduction

Gold is unquestionably one of the most important raw materials in human history. This importance has two meanings. Firstly, gold remains the most popular precious metal, mined by mankind continuously for several thousand years. It is used primarily in jewelry and industry. The other meaning of this importance is gold as an investment value store and investment object. In this paper, this last-mentioned application is crucial, as it concerns an indirect method of investing in gold through the stocks of companies that mine it, offering an interesting alternative to investing in physical gold but not necessarily to the traditional stock market as the authors assume that gold mining stocks might perform significantly differently from the stock market in a broad sense. The mentioned assumption is well argued by studies that relate to the relationship between the price of gold and gold mining stocks return, for example, studies mentioned in the literature (Blose and Shieh 1995; Tufano 1998;

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Twite 2002; Faff and Hillier 2004; Fang et al. 2007; Johnson and Lamdin 2015; Szczygielski et al. 2018). According to the regression analysis, gold mining stocks have greater exposure to gold price returns than stock market returns. In most studies, a gold leverage effect was observed, which takes place when the gold beta is greater than one (Baur 2014), but there are also exceptions where the effect didn't occur (Twinte 2002; Coleman 2010). However, the issued publications have a few problems, especially for today's investors.

In most cases, studies relate only to one peculiar market, mainly Australia (Faff and Chan 1998; Twite 2002) and North America (Tufano 1998; Coleman 2010). Financial markets have provided investors with easy access to Exchange Traded Funds, which can assure diversified exposure for gold mining stocks worldwide. Additionally, in the majority of research, a very distant period is adopted, which frequently started in the previous century. The authors believe there is a need to re-examine the performance of gold mining stocks in the new global economic reality after the global financial crisis (2007–2009) and until the end of the SARS-Cov-2 pandemic. This paper assesses whether nowadays the quoted stock prices of global gold mining raw material companies are derived from the quoted price of the raw material and, should this be the case, if such stocks are subject to the gold price leverage effect. The research will describe the relationship between the rate of return of diversified gold mining stocks and the rate of return of gold and the stock market during 2011–2020.

1. Nature of the gold market

The gold market has seen extreme volatility with regard to the price of this commodity in recent years, triggered by both market and non-market factors. It would appear that similar to the other goods, the most significant determinant of the gold price, alongside supply, is demand, specifically the expressed level of demand for it. An analysis of a cause-effect relationship between the price of gold (expressed in USD/oz) and the demand for it (expressed in Mg) conducted by (Iwaszczuk et al. 2021b) reveals that the level of correlation between the variables amounts to a mere 0.237. A surprisingly low correlation between the price of gold and the demand for it may indicate that the gold market functions somewhat differently than the traditional goods market. The demand for gold is present in multiple markets, while the core types of demand for this element include: jewelry demand, industry and medical demand, investment demand, net-implied investments, official sector demand, and the demand from the gold producers (de-hedging) (Mamcarz 2014a). Figure 1 below presents how the gold demand has changed over the past decade.

Gold holds a unique position among all metals, with only 10% of its demand coming from the actual industry (Naser 2017). The figure above reveals that over the past decade, the total demand for gold has been relatively stable. Jewelry represents the highest share, excluding 2020, which was a year of great uncertainty in the financial markets caused by the COVID-19 pandemic. While demand from the jewelry sector was significantly reduced,

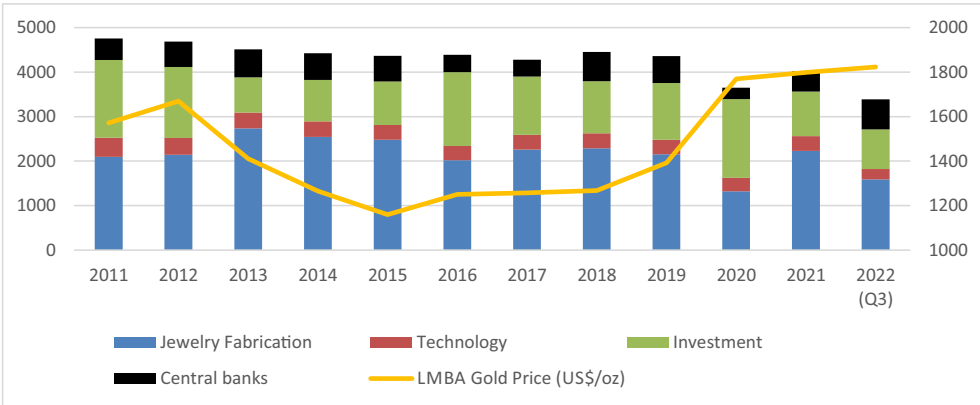

Fig. 1. Global demand on the gold market 2011–2022 (Mg)
Source: own research based on (Goldhub 2023)

Rys. 1. Globalny popyt na rynku złota w latach 2011–2022 (Mg)

there was a noticeable increase in the demand from the financial sector. The investors relocated capital to gold, recognized as one of the safest assets, which also gains value in times of crisis. The demand of central banks might seem insignificant; however, the gold price is also affected by how much gold central banks store and emit to the global market (Aizenman and Inoue 2013).

Irrespective of the conditions, an essential factor determining the level of demand for gold is its price. The figure above reveals that, when it comes to bullion demand, the relationship between these two economic categories is by no means obvious, since, for instance, there has been a noticeable price increase of raw material in recent years, with a simultaneous increase in investment demand. This situation proves that gold is particularly important to investors, who are definitely not driven by price alone when purchasing it, which is the case with many other investment assets. As for the supply of gold, its primary sources are identified as: gold mines production, hedging, official sector and recycling (Shafiee and Topal 2010). A major factor affecting the supply of raw material is the cost of its production, which vary by location and by mining method. The analyses aimed at a quantitative assessment of the correlation between the individual costs of mining operations and the market price have proven that the costs play a crucial role in price development (Aguilera and Radetzki 2018). The research revealed that the costs of an extra new supply are strongly correlated with the price levels. This correlation has been confirmed over four decades, with periods of sharp price increases (circa 1980 and 2010). The gold price is affected while mines produce more or less gold and augment the circulating supply around the world (Gutiérrez et al. 2013). Figure 2 below presents how the gold supply has changed over the past decade.

Gold supply has remained remarkably stable over the past decade, including the COVID-19 pandemic year of 2020, which saw a marginal decrease in production com-

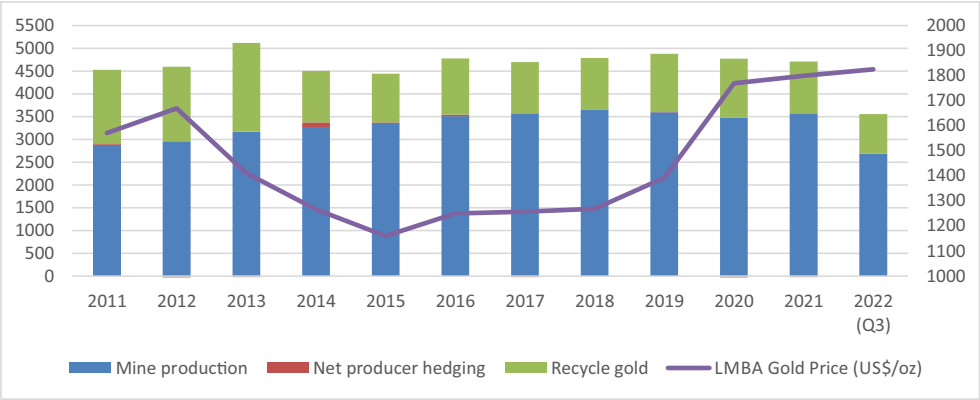

Fig. 2. Global supply on the gold market over the 2011–2022 period (Mg)
Source: own research based on (Goldhub 2023)

Rys. 2. Globalna podaż na rynku złota w latach 2011–2022 (Mg)

pared with the previous year. In the 2011–2020 period, mining operations were by far the most significant contributor to the supply of raw material, supplemented with recycling in the form of the secondary treatment of coins, jewelry, electronics, and scrap. A factor determining the extent of recycling is the price of gold since extracting raw material from the components is a very costly process (Mamcarz 2014b). High bullion prices motivate owners of antique gold and these components to sell them, and the recycling itself becomes more profitable with elevated gold prices; where low prices mean that a lot of gold-containing scraps are not recycled at all since it is not cost-effective. The correlation described can be noticed with particular ease in 2011 and 2012, where, with record high bullion prices, recycling has delivered more than 1600 Mg of gold in two consecutive years, accounting for some 35% of production at the time. The global gold supply is complemented by the producers' net hedging effect. A high gold price volatility on the global commodity exchanges demands extra caution from the mining companies in their mining operations and forces them to secure income from their future production (Mamcarz 2014b). Incorrect predictions with regard to raw material prices led to a negative hedging effect in 2012, 2013, 2017, 2018 and 2020.

Gold is analyzed in the literature as a raw material, an object of both direct and indirect investment, and its price development is largely determined by the supply and demand associated with its physical use (jewelry, industry) and an investment demand for bullion, which is also a manifestation of the financialization process (Kasprzak-Czelej 2018). In general, gold price is mainly affected by three factors: the proven reserves of gold and energy prices, financial market and macroeconomic factors (Lili and Chengmei 2013). These are not the only gold price determinants, however, as it is also strongly influenced by, for example, economic and political changes, financial and fuel crises and any other global events (Iwaszczuk et al. 2021a). The main factors influencing the gold price in global markets are

identified as the USD/EUR exchange rate, long-term S&P 500 index rate of return, Brent oil price changes, United States ten-year bond yields, and the gold price's behavior in past periods (Bukowski 2016).

These factors determining the gold price can be divided into short-term and long-term factors. Short-term gold price determinants include, among other things, turmoil of raw material markets (oil market in particular), speculative investors' behavior, including arbitrary actions (exploiting price differences in the US, Asian, European markets), herd behavior and a crowd craze (which are often irrational and not based in reality), country rating changes information, short-term exchange rate changes, inflation rate, stock market indices and current updates on the economic situation and political developments (Bukowski 2016). Additional short-term gold price determinants are the USD purchasing power parity, seasonality and the public sector's behavior in the gold market (Mamcarz 2015). In the long-term, the gold price is determined by the phase and course of the business cycle, long-term inflation expectations, long-term stock market trends, long-term United States bond yields (inverse correlation with gold), US, OECD countries, Chinese and Indian economy development forecasts, expectations for the exchange rates and a global economy (Bukowski 2016). Further long-term gold price determinants are global population growth, investment demand, the volume of bullion produced by mines and the phase of the raw material cycle (Mamcarz 2015).

2. Gold price leverage

Popular forms of investing in the gold market include investing in jewelry, bullion bars and coins, trust and ETF funds, futures and option contracts (Nawaz and Sudindra 2013). Investing in stocks of mining companies is among the less obvious methods of obtaining exposure to the gold market. These include companies engaged in prospecting for raw material deposits and those that later extract them (Schwarze 2009). Investing in gold mining companies' stocks offers several advantages over a traditional investment in physical gold. The most common examples of such advantages include: higher potential returns, dividends received, simple and swift transactions, the opportunity to invest smaller sums. Investing funds in the stocks of gold mining companies constitutes one of the riskiest forms of participation in the gold price level change for investors. In addition to the advantages mentioned above with regard to investing in gold mines' stocks, investors opt for a much higher risk related to buying physical gold, as they hope for a high and positive gold price leverage. In this article, leverage is understood as:

- the ratio of the relative mining company stock price level change to the relative gold price change that determines it;
- the quotient of the rates of return of stock and gold.

The leverage translates into a greater percentage change in the stock price than the change in the gold price that causes it. In other words, for this effect to occur, the price change ratio must exceed one. This indirectly depicts the level of risk that a given company is exposed

to. The risk of the investment and the potential income will be directly proportional to the leverage level we are dealing with, i.e. the amount of the company's participation in changes in the bullion price level. An increase in gold price determines the positive effect of the gold price leverage (leverage shows an upward trend), while a decrease in the gold price level will cause the negative effect of the gold price leverage (leverage shows a downward trend). In the case of mining companies, gold price leverage results from the strong response of a company's profit change due to fluctuations in the bullion price. Production costs are an important factor that determine the profitability of a gold mine; to assess production profitability, it is essential to identify total costs (all in cost), which vary worldwide and over time (Mamcarz 2017). The value of a gold mine might be considered as the function of the return on gold, production costs, the level of gold reserves, and the proportion of assets unrelated to gold price risk (Blose and Shieh 1995). With relatively stable raw material mining costs, its price might significantly define the company's level of profit which then translates into its stock price. The higher the company's total costs, the bigger the profit change of a mining company; this is a consequence of the gold-price change. In appropriate conditions, even minor gold price changes in global commodity markets can be responsible for the significant changes in the stock-price level of the gold mining companies. The profit volatility of mining companies in relation to the gold price behavior is illustrated in the following hypothetical example.

Table 1. Leverage caused by a gold price change – an example

Tabela 1. Efekt dźwigni spowodowany zmianą ceny złota – przykład

Variable	Values	10% price decrease	10% price increase	Change with a 10% gold price decrease		Change with a 10% gold price increase	
				USD/oz	%	USD/oz	%
Experienced gold producer							
Average realized gold price (USD/oz)	1,500	1,350	1,650	–150	10	150	10
Gold all-in sustaining costs (USD/oz)	1,000	1,000	1,000				
Gross margin (USD)	500	350	650	–150	30	150	30
Initial gold producer							
Average realized gold price (USD/oz)	1,500	1,350	1,650	–150	10	150	10
Gold all-in sustaining costs (USD/oz)	1,300	1,300	1,300				
Gross margin (USD)	200	50	350	–150	75	150	75

Source: own research.

The above calculations indicate that a 10% average realized gold price increase (decrease) caused a 30% sales gross margin increase (decrease). There was a three times higher relative response of the gross margin as compared to the average realized gold price level change. A second simulation is also performed in Table 1 for a hypothetical, somewhat less experienced producer operating closer to the break-even point, with a total assumed gold all-in sustaining costs of USD 1300/oz. A 10% average realized gold price increase (decrease) resulted in a 75% gross margin increase (decrease). In this scenario, there was a seven times higher relative response of the gross margin as compared to the average realized gold price level change. The second company's much greater bullion price change sensitivity is that it incurs much higher mining costs. Nevertheless, in either case, a raw material price increase causes a manifold increase in the level of profits generated by the companies, which will translate into their stock price increase (positive leverage effect); similarly, a raw material price decrease causes a manifold decrease in the level of profits generated by the companies, which will have a negative effect on their stock price (negative leverage effect).

3. Methodological assumptions and research purposes

As the price of gold is a peculiar variable which determines the stock price levels of the mining companies, it appears that such stocks can be considered as a derivative instrument, for which gold is the underlying instrument. However, stock price quotes of the gold mining companies should follow the widely understood stock market to a certain extent, similar to many companies in other sectors.

In the process aimed at assessing the impact on the gold mining companies stock price, it might be helpful to establish the values of the gold beta and market beta coefficients:. However, in this paper, the beta coefficient has the same meaning as in stock markets, i.e. market risk measure. In the analyzed case, the gold beta coefficient represents a measure of the mining companies' stock price exposure to the gold price, while their measure of stock market exposure is the market beta coefficient. The said gold price leverage could theoretically occur when the gold price changes. Investors taking long positions on gold mining companies expect a high gold price leverage. Gold mining and extracting companies face their own specific risks, and it would appear that investing capital in their stocks should, to some extent, be determined by what phase the market is currently in and where it is headed. Historically, stock market crashes are accompanied by the simultaneous flight of investors to gold, which is considered to be a safe asset (Buccioli and Cocholm 2022). For the mentioned assets, there is a relationship that during the extreme financial crisis, investors escape from the stock markets, including gold mining stocks to physical gold. If the financial crisis is less intense, the investors' escape from stocks still occurs but excluding gold mining shares (Baur et al. 2021).

Questions still arise regarding what the impact is of these two factors on the mining companies' stock prices and what the relationship between them is. Therefore, this paper aims to assess whether the quoted stock prices of gold mining companies are derived from the

quoted price of the raw material and, should this be the case, if such stocks are subject to the gold prices leverage effect. The following research hypotheses were formulated according to the objective set:

1. Gold price changes have a more substantial impact on the mining companies' stock prices than stock market level changes.
2. Investments in the mining companies' stocks trigger a gold price leverage effect.

To achieve the outlined purpose, Sharpe's single-index model (Sharpe 1963) was employed. Two models were developed on its basis to be able to measure the desired relationships, and they took the following form:

$$R_{IAUP} = \alpha_1 + \beta_1 R_{DJI} \tag{1}$$

and

$$R_{IAUP} = \alpha_2 + \beta_2 R_{Au} \tag{2}$$

- R_{IAUP} – the rate of return on a fund representing gold mining companies,
- α_1, α_2 – an absolute term of the equation,
- β_1 – stock market beta,
- β_2 – gold beta,
- R_{Au} – the rate of return on gold denominated in USD,
- R_{DJI} – the rate of return on the Dow Jones Index representing the stock market.

Investors are usually interested in the risk-return relation of their assets, in which their allocated funds. The above regression models will enable measurement of the systematic risk of gold mining stocks, which depends on the correlation between them and the gold market or stock market. The beta coefficient, which is also called the coefficient of aggressiveness (Dembny 2005; Tarczyński et al. 2013) expresses the systematic risk of the asset versus the reference factor volatility (Bisceglia and Scigliuto 2016). The beta factor is calculated according to the following formula (Sharp et al. 1995; Pera et al. 2014):

$$\beta = \frac{\operatorname{cov}\left(R_i, R_m\right)}{\sigma_m^2} \tag{3}$$

Stock market beta expresses the systematic risk of the gold mining stocks with regard to the board stock market, and gold beta expresses the systematic risk of gold mining stocks regarding to gold market. Calculating both coefficients will enable classification of the exposure of gold mining companies on the stock and gold market as in the Table 2.

Research on the time series stationarity using the augmented Dickey-Fuller test was conducted before the calculations. The research also employed descriptive analysis and basic

Table 2. Interpretation of gold and market beta levels

Tabela 2. Interpretacja poziomów parametru beta rynku i beta złota

β	Market beta	Gold beta
< 0	The gold mining stocks' rate of return responds in the opposite direction from the stock market's rate of return.	The gold mining stocks' rate of return responds in the opposite direction from the gold market's rate of return.
$= 0$	The gold mining stocks' rate of return responds independently to the stock market's rate of return.	The gold mining stocks' rate of return responds independently to the gold market's rate of return.
$0 < \beta < 1$	The gold mining stocks' rate of return is less volatile than the stock market's rate of return – it is defensive against the stock market.	The gold mining stocks' rate of return is less volatile than the gold market's rate of return – it is defensive against the gold market.
$= 1$	The gold mining stocks' rate of return is exactly as volatile as the stock market's rate of return.	The gold mining stocks' rate of return is exactly as volatile as the gold market's rate of return.
> 1	The gold mining stocks' rate of return is more volatile than the stock market's rate of return – it is aggressive against the stock market.	The gold mining stocks' rate of return is more volatile than the gold market's rate of return – it is aggressive against the gold market.

Source: own research based on Jajuga K. and Jajuga T. 2008.

descriptive statistics, initially calculated for the quotes of the analyzed variables and, subsequently, for their rates of return. The research covers the ten-year period from September 2011 to September 2020. September was deliberately chosen as the month when the analysis started and ended. For both 2011 and 2020, it was a very successful month for gold, with its current price on global commodity exchanges being around USD 1800–2000/oz.

The research was conducted based on quotes published on the last working day of the given month: SPOT gold price in USD, ETF representing gold mining companies, iShares Gold Producers and the Dow Jones Industrial Average Index representing the stock market. These quotes were used to calculate the logarithmic rates of return on which the research was based. A classical least squares method was used to establish the structural parameters of the model (alpha and beta). The above-mentioned iShares S&P Gold Producers UCITS (IAUP) is a passive ETF that mimics the S&P Commodity Producers Gold Index, founded in 2011, grouping more than fifty gold mining companies that operate on six continents. The Dow Jones Industrial Average (DJI) is definitely one of the most important stock market indices. It is comprised of the thirty biggest companies listed on the American stock exchanges: New York Stock Exchange and NASDAQ. This analysis was based on empirical data published by investing.com and Stooq portals. The stock rates used in this calculation took payable dividends into account.

4. Analysis of the rate behavior of the examined variables

A visual analysis of Figure 3 alone reveals that the mining companies stock price quotes, as measured by the IAUP fund, follow the gold price quotes. Gold price increases are followed by IAUP fund rate increases, the relationship obviously works both ways; gold price decreases are followed by an immediate weakening of the ETF-accepted rate.

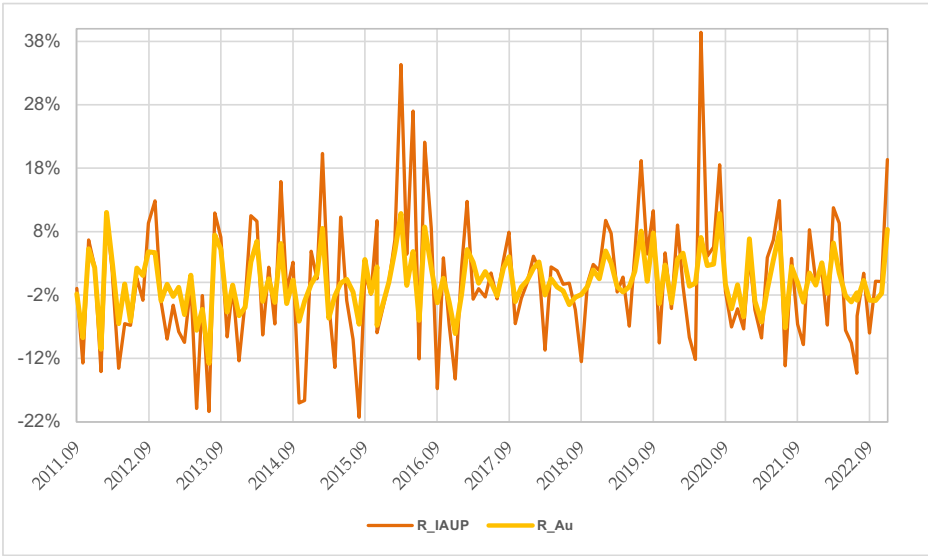

Fig. 3. Monthly returns of the iShares Gold Producers ETF and gold (USD) 2011–2022
Source: own research based on data Stooq 2023

Rys. 3. Miesięczne stopy zwrotu ETF iShares Gold Producers oraz złota (USD) w latach 2011–2022

The chart shows that much higher volatility occurs in the case of gold mining companies. The observation is supported by the estimated monthly returns for the assets under study, which show that mining companies are more than twice as volatile as relatively stable gold. The standard deviation of returns for companies is 10.2% compared to 4.42% for gold, which confirms the belief that it is a good option for investors looking for security and low volatility. The Persona linear correlation coefficient for the analyzed period was: $r = 0.85$, which identifies the existence of a strong positive linear relationship between the measured quantities.

When we analyze the relationships between the gold price and the Dow Jones Index level, things look different. It can be easily observed in Figure 4 that in many cases, the quotes of mining companies (IAUP) behave rather differently than the stock market represented by the Dow Jones Index. It applies to almost the entire research period, particularly 2011–2015, when it is obvious that the analyzed assets are headed in entirely different directions, despite the current bull market for stocks, mining companies have seen very steep declines.

Table 3. Correlation matrix and basic descriptive statistics for the IAUP fund, gold price and Dow Jones Index 2011–2020

Tabela 3. Macierz korelacji oraz podstawowe statystki opisowe dla funduszu IAUP, ceny złota oraz indeksu Dow Jones w latach 2011–2020

Variable	IAUP	Gold	Dow Jones
IAUP	1		
Gold	0.904905358	1	
Dow Jones	–0.326553569	–0.06178706	1
Descriptive statistics	IAUP	Gold	Dow Jones
Mean value	USD 11.40	1,379.25 USD/oz	19,526.23 pts
Standard deviation	USD 4.31	208.72 USD/oz	4,933.67 pts
Coefficient of variation	37.82%	15.13%	25.27%

Source: own research.

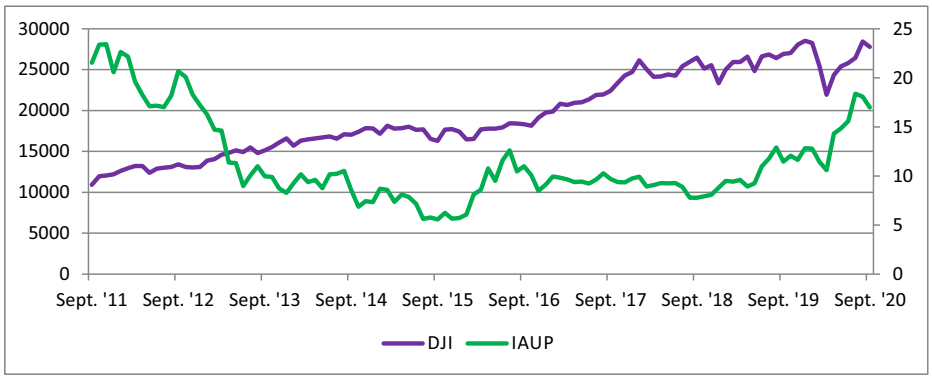

Fig. 4. ETF iShares Gold Producers and the Dow Jones Industrial Average index 2011–2020
Source: own research

Rys. 4. ETF iShares Gold Producers oraz indeks Dow Jones Industrial Average w latach 2011–2020

As expected, the Dow Jones Industrial Average Index representing the entire stock market displayed less volatility than ETF which only provides exposure to the very difficult and challenging gold mining sector. The coefficients of variation stood at 25.27% for Dow Jones and 37.28% for the iShares fund, respectively. As for the correlation coefficient for the entire period, it was low and negative (eventually amounting to: $\rho = -0.33$), giving grounds to the assumption that the development of the stock market does not have a significant impact on the mining companies' stock quotes, with the gold price being considered the main determinant.

The stock market is one of the first alternatives on the horizon for investors who are not interested in gold. This finding is confirmed by many studies showing that gold is uncorrelated with the stock market during regular times and during times of crisis (Baur et al. 2021). However, the highly prevailing bull market on the stock market may successfully draw the attention of many investors away from the precious metals market. The situation has now been reversed upon the occurrence of what we call a "black swan" in the global economy – an unforeseeable situation that triggers stock market turmoil. It is the time when investors transfer their capital into gold, which performs considerably better than stocks. Such a situation was clearly seen in the recent past in March 2020 at the onset of the COVID-19 pandemic (Morales and Andreosso-O'Callaghan 2020). A similar relationship was also observed several years earlier in 2007–2008 during the crisis triggered by the US real-estate market crash and also during the Eurozone debt crisis of 2010, when gold performed relatively well compared to other assets (Mulyadi and Anwar 2012). The correlation coefficient for Dow Jones and the gold price in USD for the research period was: $\rho = -0.06$, indicating a lack of a linear relationship between the analyzed variables. Due to the low or even negative correlation with a large amount of assets, gold constitutes a significant part of an investment portfolio for many investors.

5. Research findings

Table 4 illustrates that the stock market performed considerably better during the research period than the gold market. The Dow Jones Index provided considerably greater earning capacity compared to bullion investments, reaching an average monthly rate of return of 0.87%, which, compared to the gold's result of just 0.14%, is over six times better. The situation is even worse for mining companies, where an investment guaranteed a monthly loss of about 0.22%. Gold mine stocks were also the most volatile asset. They could gain over 30% compared to the previous month, to fall by over 25% in another month. It is also reflected in the coefficient of variation, where ETFs representing mining companies together with gold reached a four-digit result, $V_{IAUP} = 4.722\%$ and $V_{Au} = 3.177\%$ respectively, clearly outperforming the rates of return coefficient of the Dow Jones index, which stood at $V_{DJI} = 445\%$. By contrast, the skewness coefficient assumed a negative value, which indicates that the Dow Jones rates of return are characterized by a leftward asymmetry. This is not a desirable situation for investors, as it results in a higher probability of being assigned to lower rates of return (Pera et al. 2014). For the gold price and iShares fund, the skewness coefficients were almost zero, a practical indication of no asymmetry. Positive kurtosis coefficient values were observed for all analyzed variables. It was only 0.09 for gold, which means that, among the analyzed variables, the distribution of gold rates of return resembles a normal distribution the most. Things are slightly different for the Dow Jones, with a kurtosis coefficient of 2.58. This indicates a relatively strong concentration of its rates of return around the mean.

Table 4. Descriptive statistics for the monthly IAUP fund, gold and the Dow Jones Index rates of return

Tabela 4. Statystyki opisowe dla miesięcznych stóp zwrotu z funduszu IAUP, złota oraz indeksu Dow Jones

	Mean (%)	Median (%)	Minimum (%)	Maximum (%)
R_IAUP	–0.22	–0.27	–25.23	30.15
R_Au	0.14	–0.26	–11.72	10.62
R_DJI	0.87	0.99	–14.79	10.51
	Standard deviation (%)	Coefficient of variation (%)	Skewness (%)	Kurtosis (%)
R_IAUP	10.41	4,722	0.12	0.58
R_Au	4.40	3,177	0.02	0.09
R_DJI	3.85	445	–0.90	2.58

Source: own research.

With regard to the research conducted, it is worth noting that both explanatory variables satisfy a model analysis condition, as they exceed (several dozen times) a minimum coefficient of variation value (V = 10% is assumed as a limit). Moreover, there is no collinearity between the rate of return and the predictors, the correlation coefficient was close to zero, as shown in the Table 5.

Table 5. A correlation matrix for the monthly IAUP fund, gold and the Dow Jones Index rates of return

Tabela 5. Macierz korelacji dla miesięcznych stóp zwrotu z funduszu IAUP, złota oraz indeksu Dow Jones

Variable	R_IAUP	R_Au	R_DJI
R_IAUP	1		
R_Au	0.830393472	1	
R_DJI	0.152376739	0.0514669	1

Source: own research.

Any attempt to estimate the desired parameters should be preceded by a verification process to determine whether the variables on which the calculations will be performed are stationary or non-stationary. In practice, checking for the stationarity of a given time series is performed by verification of the null hypothesis assuming the presence of a unit root (Staszczyk 2017). To examine this aspect, an augmented Dickey-Fuller test was performed. This analysis was conducted with the GRETL software. Furthermore, an auxiliary graph illustrating how the analyzed variables behave over time was created for this purpose.

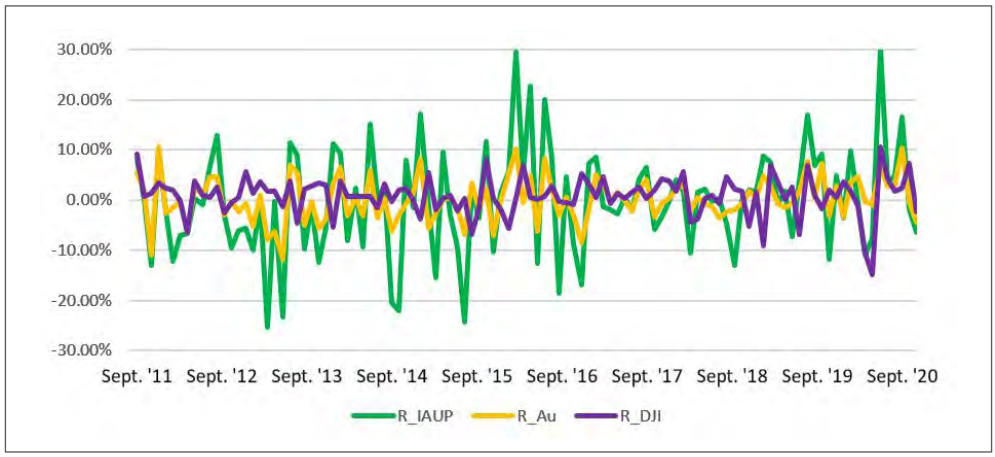

Fig. 5. Rates of return chart for the analyzed variables
Source: own research

Rys. 5. Wykres stóp zwrotu badanych zmiennych

The stationarity of the process means that the main distribution parameters, such as the expected value, variance and covariance, should assume constant values, i.e. independent of time (Krężołek 2020). It can be intuitively assumed that a stationary variable is a variable for which the properties remain unchanged over time. Every stochastic process in which any parameter is unstable over time is regarded as a non-stationary process (Krężołek 2020). After conducting a preliminary visual analysis, it would appear that the series are presumably stationary. The chart for each variable indicates neither an upward, nor a downward trend. There is no linear or curved trend to be found. These assumptions were confirmed through the GRETL analysis. For each test conducted, the p-value was below the assumed alpha = 0.05. This implies that, in all three tests, there is a basis for rejecting the null hypothesis assuming the unit root presence, which indicates that the analyzed series are stationary.

Table 6. P-value for the analyzed variables

Tabela 6. P-value dla badanych zmiennych

	R_IAUP	R_Au	R_DJI
P-value	1,611E-14	3,126E-15	2,158E-11

Source: own research.

The Table 7 presents the values of unknown parameters α_1, β_1, α_2, β_2 determined by the least squares method.

Table 7. Alpha and beta coefficient values for the explanatory variables of the gold price and the stock market

Table 7. Wartości współczynnika alfa i beta dla zmiennych objaśniających ceny złota i rynek akcji

Explanatory variable	Parameter alpha	Parameter beta
Market rate of return	0.007958503	0.458378327
Rate of return of gold	–0.003972797	1.981067262

Source: own research.

Ultimately, the models depicting the relationship between the gold mine stock price and the adopted explanatory variables are as follows:

$$R_{IAUP} = 0,007958503 + 0,458378327 R_{DJI} \tag{4}$$

$$R_{IAUP} = -0,003972797 + 1,981067262 R_{Au} \tag{5}$$

Conclusions

The resulting alpha parameter value was positive for the stock market but negative for the gold market. In the single-index Sharpe model, this parameter indicates the expected stock rate of return, provided that the expected rate of return specific to the market factor is zero; it also shows what portion of the expected rate of return is not sensitive to the market factor changes (Pera et al. 2014). The quoted properties indicate that it is to the investor's advantage if the instruments he holds are characterized by the highest possible value of the alpha parameter. The market's alpha is performing better in this respect it has, however, achieved a near zero value, which is similar to gold's alpha. This means that any stock price developments, in the absence of explanatory variable fluctuations, will be marginal. With the stagnant stock market, gold mining companies are expected to see a slight rate level increase. It is just the opposite with the stagnant gold market, when the gold mines' stock prices will see slight declines.

The beta parameters for the above models represent the gold mining companies' stock rate of return elasticity (iShares Gold Producers) relative to, respectively, the stock market rate of return, represented by the Dow Jones Industrial Average index (β_1 – stock market beta) and the gold price rate of return in USD (β_2 – gold beta). If we round the obtained beta coefficient values, it amounts to 0.45 for the stock market and 1.98 for the gold price, respectively. When the Dow Jones Index increases (or decreases) by 1%, the rate of the ETF representing mining companies increases (or decreases) by roughly 0.45% on average;

when the gold rate increases (or decreases) by 1%, the rate of the ETF representing mining companies increases (or decreases) by roughly 1.98% on average. According to Table 2, gold mining companies' stock can be described as defensive to the stock market (the gold mines' stock rate of return is not sensitive to the market development) and aggressive to the gold market (the gold mines' stock rate of return is more responsive than the gold price change).

During the research period, gold price changes impact gold mines' stock prices over four times stronger than stock market level changes. Mining companies' stock price change is almost twice the gold price change. The research hypotheses prove valid in light of the research findings. The stock price of gold mining companies is primarily affected by the gold price level change; investment in these stocks provides the gold price leverage effect. The research revealed that the gold mining companies' stocks constitute a leveraged derivative of sort, with the gold price functioning as the underlying asset.

The results of conducted research support those of previous studies. Despite huge changes in the global economy that have occurred in past decade, the relationship between gold, stock market and gold mining companies is similar. Gold mining stocks have a greater exposure to gold price return than to stock market return. The investors who believe in gold price increase should consider allocating part of investment capital in gold mining stocks in order to maximize potential profits.

Publication prepared within the statutory research of Department of Investments at the University of Economics in Katowice.

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GOLD MINING STOCKS – AN INVESTOR'S PERSPECTIVE

Keywords

risk, gold, financial leverage, rate of return, Sharpe model

Abstract

In this article, gold is analyzed from an investment perspective as an asset that allows you to increase your wealth. The analysis is twofold. First, it is about examining to what extent changes in gold prices in the world markets translate into changes in the prices of shares of companies that extract gold. Second, it was checked whether there is a financial leverage effect, which in this case means that changes in the price of shares of gold mining companies are greater than changes in the price of gold itself. Methodically, the Sharpe model was used and two basic parameters of the model were estimated, i.e. the intercept (alpha), and the beta coefficient as a measure of systematic risk, for the gold market and the equity market of gold mining companies and ETFs based on these companies.

The research carried out in accordance with the logic of the Sharpe model shows that the obtained value of the alpha parameter for the stock market was positive, while for the gold market it was negative. At the same time, higher levels of this parameter are beneficial to the investor, which means that an advantage of the stock market over the gold market exists. In turn, the estimated beta for the stock market is much lower than for the gold market. The systematic risk level for stocks is 0.45, and for the gold market it is 1.98, which is a significant difference. The stocks of gold mining companies can be classified as defensive against the stock market (the rate of return of the gold mine stock is insensitive to market movements) and aggressive against the gold market (the rate of return of the gold mine shares reacts more strongly than the movement in the price of gold).

AKCJE SPÓŁEK WYDOBYWAJĄCYCH ZŁOTO – PERSPEKTYWA INWESTORA

Słowa kluczowe

ryzyko, złoto, stopa zwrotu, dźwignia finansowa, model Sharpe'a

Streszczenie

W niniejszym artykule złoto jest przedmiotem analizy z inwestycyjnej perspektywy, jako walor pozwalający pomnażać kapitał. Przy czym analiza jest dwojakiego rodzaju. Po pierwsze, chodzi o zbadanie, na ile zmiana cen złota na rynkach światowych przekłada się na zmiany cen akcji spółek, które złoto wydobywają. Po drugie, jeśli taki związek istnieje, to sprawdzono czy występuje efekt dźwigni finansowej, polegającej w tym przypadku na tym, że zmiany cen akcji spółek wydobywających złoto są większe od zmian cen samego złota.

Metodycznie posłużono się ideą modelu Sharpe'a i oszacowano dwa podstawowe parametry modelu, czyli poziom wyrazu wolnego alfa, oraz współczynnik beta, jako miara ryzyka systematycznego każdorazowo dla rynku złota oraz rynku akcji spółek wydobywających złoto oraz funduszy ETF bazujących na tych spółkach.

Z przeprowadzonych badań zgodnie z logiką modelu Sharpe'a wynika, że uzyskana wartość parametru alfa dla rynku akcji była dodatnia, natomiast dla rynku złota ujemna. Przy czym wyższe poziomy tego parametru są korzystne dla inwestora, co oznacza przewagę rynku akcji nad rynkiem złota. Z kolei oszacowany współczynnik beta dla rynku akcji jest zdecydowanie niższy niż dla rynku złota. Dla akcji poziom ryzyka systematycznego wynosi 0,45, a dla rynku złota 1,98, co jest różnicą istotną. Akcje spółek wydobywających złoto można zaklasyfikować jako defensywne względem rynku akcji (stopa zwrotu akcji kopalni złota jest mało wrażliwa na zmiany rynkowe) oraz agresywne względem rynku złota (stopa zwrotu akcji kopalni złota reaguje silniej niż zmiana ceny złota).