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## Article

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## STRATEGIC APPROACH TO INVESTMENT PORTFOLIOS THROUGH THE PRISM OF PRECIOUS METALS

**Martina Marinac<sup>1</sup>**  
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### **Abstract**

Within finance, there is an area of investment based on the role in investment opportunities that are expected to increase in value in the short or long term, further to this, will also increase a profit for the investor. Depending on preferences, risk propensity and available trading facilities, investors make decisions about the components of their own investment portfolios. The general premise on the basis of which investors decide is to make as much profit as possible, and at the lowest possible rate of risk. In order to meet this unwritten rule, investors must focus their investments on more investment options, which is diversify of the investment portfolio; what is also what modern portfolio theory, or Markowitz's theory, is about. In this way, the risk is allocated to several smaller segments or investment options and potentially achieves a higher return on investment than would be realized if all available funds were directed to one investment object. Diversification, in practice, serves as an effective investment tool that provides the investor a protection against risk, but it is also a tool to achieve the basic goal of investment, or profit for which the investor stands.

Keywords: investment; portfolio; precious metals; diversification; modern portfolio theory

*JEL Classification:* F01, Z32

### **INTRODUCTION**

It is a well-known statement that money makes the world go round, and life without it is unthinkable. With target of making a profit starts all business, from business entities to market players, but also the individual in general. An individual with the intention of accumulating funds and building their own fortune often reaches for the investment option. As in investing with the target of creating material fortune, so in all other segments of life, invested money or, in other words, effort over a period of time confirms the increase in value. Generally speaking, the investment activity sets the investor the task of choosing the most affordable investment option in the form that, within their own capabilities, will be able to achieve the highest return and return on investment accompanied by the lowest possible values of risk. In today's globalized world, where changes in financial markets are very frequent, which makes business activities unpredictable, one of the ways to minimize investment risk is to diversify the portfolio. The investment process itself has been known for a long time, and it has been established that investments in specific funds provide their investors protection against risk. One of

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such so-called "safe" investment options are precious metals because, due to their specific chemical and physical properties and rarity and irreplaceability, they do not lose value. The prices of precious metals are considered more stable over time because they are less dependent on business cycles if they are compared with other objects of trade or investment. For these reasons that investments in precious metals are often included in investment portfolios for a more robust and less volatile portfolio. The purpose of this scientific paper is, in addition to clarifying the theoretical assumptions and facts about precious metals themselves, diversification and modern portfolio theory, to prove the diversification benefits of precious metals. Therefore, the aim of this scientific paper is to optimize the investment portfolio by adding precious metals as components of which gold, silver and platinum have been selected for the purposes of this paper; and observing their impact on overall portfolio efficiency, both in terms of return on investment and risk measured by standard deviation and Sharpe ratio.

## 1. INVESTMENTS IN PRECIOUS METALS

When deciding on an investment, the investor must determine what will be the subject of his investment, determine the investment costs and expected income and, based on the collected data, generate information on the profitability of the considered investment.

Investing is possible in real (tangible) assets, financial assets and investments equated with them, as well as so-called intangible assets<sup>2</sup>. Financial investments include investments in bonds, stocks, commercial papers, options and other financial securities.

On the other hand, untouchable assets are investments focused on human resources, patents, goodwill, licenses and more. Finally, investing in real assets refers to investing in tangible, that is, tangible goods such as equipment, land, buildings, ecc. Therefore, investments can be directed to specific goods such as precious metals. Such investments can take the form of investments in real or tangible assets, because in their essence they are actually tangible goods; but they can also be considered as investments in financial assets if the investment is directed, for example, to shares, options or mutual funds.

The threat in the form of depreciation of precious metals is in the discovery of new sources of ore or improvements in existing mining or processing operations. They are used in various industrial processes and have had historically important role in accumulating value. The precious metals are therefore derived from their specific chemical and physical properties, and include gold, silver, platinum, palladium, iridium, rhodium, osmium and ruthenium. The most popular precious metals among investors are gold, platinum and silver.

Today, the value of gold is determined by market demand for the metal, and although it is no longer used as a standard, it still has an extremely important function. Gold is the basic financial asset of all countries and central banks. It is also used by banks to protect themselves from the potential dangers of lending to their governments and as an indicator of the economic health of countries. The past decade has seen a significant shift in central bank behavior towards gold, prompted by a reassessment of its role and relevance after the 2008 financial crisis. Merging central banks have increased official purchases of gold, European central banks have stopped selling gold, and the banking sector is now a significant source of annual gold demand. Central banks sold 7,853 tons of gold between 1987 and 2009, and between 2010 and 2016 they bought 3,297 tons.

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<sup>2</sup> Vukićević, Odošajić, *Ekonomika projekta*, 16

### **1.1. Investment in gold**

There are several ways to invest in gold. When buying gold or investing in gold, investors should consider all the options available on their market, and then determine the form of investment that will be adequate given their circumstances and opportunities. When making a decision on how to invest in gold, consideration must be given to an overview of the various investment products associated with gold. There are numerous ways to invest in gold relatively unknown to the general population. They can take the form of investing in physical or tangible gold, then ETFs and ETCs and similar funds, then allocated and unallocated gold accounts, digital investment gold or so-called "E-gold", financial derivatives, certificates, purchase of gold mine shares and ecc. The most widespread form of investment, and at the same time the most popular possibility of investing in gold, refers to the purchase of physical gold, which occurs in the form of bars, coins or jewelry.

Unlike physical gold, there are also non-tangible gold investment options for investors, so ETFs can be bought like stocks on a stock exchange. "Exchange Traded Fund" - ETF funds are translated as exchange traded funds, which allow investors easy access to gold, while avoiding additional margin costs, storage costs and security risks of holding physical gold.

The transaction costs associated with gold ETFs are often lower than the costs involved in purchasing, storing, and insuring physical gold. It is important to study the different costs, fees, and associated additional costs of each type of investment to determine the optimal and most appropriate one for a particular portfolio.

Furthermore, another option offered to gold investors is allocated gold accounts. Gold-trading banks, as well as other independent gold traders, offer their customers the opportunity to invest in gold bills, which consist of gold deposits and resemble foreign currency accounts. The moment a customer orders gold in ounces or grams, the bank will buy the requested gold on behalf of the customer and then electronically post the transaction to a so-called allocated account.

In addition, investments in gold in today's globalized and digitalized world can be realized through the so-called "Digital Gold Currency" (DGC), which is an electronic form of money backed by gold reserves stored in vaults owned by private companies that trade with them.

### **1.2. Gold values on the market**

When it comes to the value of gold, there are a number of factors that influence the final formation of the price of this precious metal itself. Starting with the gold itself, its purity and fineness are very important. In the Republic of Croatia, the degrees of purity of precious metals are prescribed by the Act on the Supervision of Precious Metal Objects, and the following table shows the purity values for gold objects.

**Table 1.** Purity of gold items in accordance with Act on the Supervision of Precious Metal Objects<sup>3</sup>

	(x/1000mass of gold in the total mass of the item)
Gold items	999 thousandths (999/1000)
	950 thousandths (950/1000)
	916 thousandths (916/1000)
	840 thousandths (840/1000)
	750 thousandths (750/1000)
	585 thousandths (585/1000)
	375 thousandths (375/1000)

Table 1 shows the values of the share of gold in an item made of it, and only values up to 375/1000 purity in Croatia are considered items made of gold.

In addition to the direct influence of the characteristics of gold on its value, many external factors affect the value of gold fluctuations such as gold reserves of central banks, produced gold, US dollar exchange rate, global industrial demand and jewelry demand, global political uncertainty, investment demand, interest rates. global economy and the like.

Gold reserves held by central banks around the world gain in value if banks diversify their monetary reserves in favor of increasing stocks and accumulating gold, while reducing the amount of monetary currencies, it can be also reverse. Many world nations have the reserves that consist mainly of gold, and over 50% of reserves kept in the form of gold in 2020 had Portugal, the United States, Germany, Italy, the Netherlands and France.<sup>4</sup>

Interest rates are another important factor in determining the price of gold. At a time of rising interest rates, attracting gold becomes much less because investors can get a better return on other asset classes that benefit from rising interest rates, such as currencies or bonds<sup>5</sup>.

As a result of all the above factors, gold values fluctuate over time and the following table will show gold prices per triple ounce in US dollars between 2000 and 2020.

**Table 2.** Prices of gold in the period from 2000 to 2020<sup>6</sup>

Year	Average price	Starting price	Highest annual price	Lowest annual price	Final price	Change per year (%)	
0.	200	\$279,29	\$282,05	\$316,60	\$263,80	\$272,65	-
1.	200	\$271,19	\$272,80	\$292,85	\$256,70	\$276,50	6.26%
2.	200	\$310,08	\$278,10	\$348,50	\$277,80	\$342,75	23.96%
3.	200	\$363,83	\$342,20	\$417,25	\$319,75	\$417,25	21.74%

<sup>3</sup> www.dzm.gov.hr (accessed June 11<sup>th</sup> 2021.)

<sup>4</sup> www.statista.com (accessed June 11<sup>th</sup> 2021.)

<sup>5</sup> www.admiralmarkets.com (accessed June 21<sup>st</sup> 2021)

<sup>6</sup> www.macrotrends.net (accessed June 21<sup>st</sup> 2021)

4.	200	\$409,53	\$415,20	\$455,75	\$373,50	\$438,00	4.97%
5.	200	\$444,99	\$426,80	\$537,50	\$411,50	\$513,00	17.12%
6.	200	\$604,34	\$520,75	\$725,75	\$520,75	\$635,70	23.92%
7.	200	\$696,43	\$640,75	\$841,75	\$608,30	\$836,50	31.59%
8.	200	\$872,37	\$840,75	\$1.023,	\$692,50	\$865,00	3.41%
9.	200	\$973,66	\$869,75	\$1.218,	\$813,00	\$1.104,	27.63%
0.	201	\$1.226,	\$1.113,	\$1.426,	\$1.052,	\$1.410,	27.74%
1.	201	\$1.573,	\$1.405,	\$1.896,	\$1.316,	\$1.574,	11.65%
2.	201	\$1.668,	\$1.590,	\$1.790,	\$1.537,	\$1.664,	5.68%
3.	201	\$1.409,	\$1.681,	\$1.692,	\$1.192,	\$1.201,	-27.79%
4.	201	\$1.266,	\$1.219,	\$1.379,	\$1.144,	\$1.199,	-0.19%
5.	201	\$1.158,	\$1.184,	\$1.298,	\$1.049,	\$1.060,	-11.59%
6.	201	\$1.251,	\$1.075,	\$1.372,	\$1.073,	\$1.151,	8.63%
7.	201	\$1.260,	\$1.162,	\$1.351,	\$1.162,	\$1.296,	12.57%
8.	201	\$1.268,	\$1.312,	\$1.360,	\$1.176,	\$1.281,	-1.15%
9.	201	\$1.393,	\$1.287,	\$1.542,	\$1.270,	\$1.523,	18.83%
0.	202	\$1.773,	\$1.520,	\$2.058,	\$1.472,	\$1.895,	24.43%

Table 2 presents historical data on gold price movements in the period from 2000 to 2020. The highest average annual value of gold in the observed period was recorded in 2020 in the amount of 1,773.73 US dollars, and the lowest in 2001 in the amount of 271.19 US dollars per triple ounce. The highest starting price of triple ounces of gold in the observed period was recorded in 2013 in the amount of 1,668.50 US dollars, and the lowest starting price of 272.80 US dollars in 2001. In total, the highest achieved annual price was recorded in 2020 in the amount of 2,058.40 US dollars, while the lowest annual price was in 2001 in the amount of 256.70 US dollars. Comparing the final gold prices at the end of each year with the previous one, the highest percentage of annual change in the positive sphere was recorded in 2007, where there was a change of 31.59% in the price of gold compared to the same in 2006. On the other hand, the largest negative percentage of annual change in the price of gold was recorded in 2013, where the price of gold fell by (-) 27.79% compared to the previous year 2012.

### 1.3. Opportunities to invest in silver

If an investor decides to add silver to their investment portfolio, there are a number of ways to do so. As with gold, investment opportunities include levers, coins, medallions, futures or forward contracts, options, funds, jewelry, and the like, and function in the same ways. Although silver, like other precious metals, is sensitive to market

fluctuations, the value of physical silver is unlikely to fall completely due to its intrinsic and actual value. Market participants can buy physical silver in various forms like silver coin, silver jewelry or lever. If a comparison is made between investments in physical silver and gold, it can be said that silver in this case offers the investor more economical and liquid investments as a result of the lower price of this precious metal.

Unlike gold bars, all silver bars and coins are subject to taxes whose rates are set by national governments. It is the payment of value added tax when investing in silver that often encourages investors to invest in gold.

Silver funds traded on the stock exchange, ETFs closely monitor the price of silver and in most cases are more liquid than the physical possession of the precious metal itself. These ETFs are mostly structured as foundations which is a typical structure for funds whose assets represent one asset that is physically kept in a vault. This structure means that each share of ownership in the ETF corresponds to a certain amount of base silver stored in the fund, which makes silver ETFs a suitable option for investors who want to own physical levers without problems with securing and storing the precious metal itself.

### 1.3.1. Silver values on the market

The final value of silver is affected by its applications and has a much greater application than just in fashion or as a storehouse of value. Precisely because of variations in the importance and purpose of the use of silver, price fluctuations in the silver market are more volatile than gold as can be seen in the illustration below.

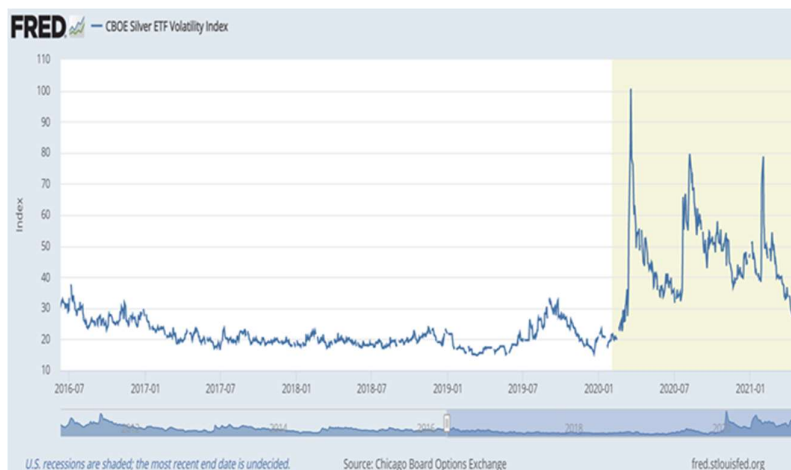


Figure 1. Graph of the volatile silver index value in the period from 2016 to 2021<sup>7</sup>

Foto 1 shows the movements of silver volatility, ie price fluctuations that are clearly shown in graphical form and especially in the period from the beginning of 2020 to 2021. Silver does not offer the same level of security as gold precisely because of the price volatility shown. However, such constant fluctuations result in greater opportunities to

<sup>7</sup> fred.stlouisfed.org (accessed June 12<sup>th</sup> 2021)

buy and sell at a profit, which only makes the investment more speculative. The volatility of silver is primarily affected by changes in the volume of industrial demand where a recession or slowdown in industrial demand encourages a depreciation of silver prices.

Below are the average prices of silver per triple ounce in US dollars in the period from 2000 to 2020.

**Table 3.** Prices of silver in the period from 2000 to 2020<sup>8</sup>

Year	Average price	Starting price	Highest annual price	Lowest annual price	Final price	Change per year (%)
2000.	\$4,95	\$5,30	\$5,45	\$4,57	\$4,58	-
2001.	\$4,37	\$4,59	\$4,82	\$4,07	\$4,52	14.07%
2002.	\$4,60	\$4,59	\$5,10	\$4,24	\$4,67	-1.31%
2003.	\$4,88	\$4,74	\$5,97	\$4,37	\$5,97	3.32%
2004.	\$6,66	\$5,99	\$8,29	\$5,50	\$6,82	27.84%
2005.	\$7,31	\$6,39	\$9,23	\$6,39	\$8,83	14.24%
2006.	\$11,55	\$9,04	\$14,94	\$8,83	\$12,90	29.47%
2007.	\$13,38	\$13,01	\$15,82	\$11,67	\$14,76	46.09%
2008.	\$14,99	\$14,93	\$20,92	\$8,88	\$10,79	14.42%
2009.	\$14,67	\$11,08	\$19,18	\$10,51	\$16,99	-
2010.	\$20,19	\$17,17	\$30,70	\$15,14	\$30,63	26.90%
2011.	\$35,12	\$30,67	\$48,70	\$26,16	\$28,18	57.46%
2012.	\$31,15	\$28,78	\$37,23	\$26,67	\$29,95	80.28%
2013.	\$23,79	\$30,87	\$32,23	\$18,61	\$19,50	-8.00%
2014.	\$19,07	\$19,94	\$22,05	\$15,28	\$15,97	6.28%
2015.	\$15,66	\$15,71	\$18,23	\$13,70	\$13,80	-
2016.	\$17,17	\$13,84	\$20,70	\$13,75	\$15,99	34.89%
2017.	\$17,07	\$16,41	\$18,51	\$15,43	\$17,13	18.10%
2018.	\$15,71	\$17,21	\$17,62	\$13,98	\$15,52	-
2019.	\$16,22	\$15,65	\$19,55	\$14,32	\$17,90	13.59%
2020.	\$20,69	\$18,05	\$29,26	\$11,77	\$26,40	15.86%
						7.12%
						-9.40%
						15.36%
						47.44%

Table 3 presents historical data on silver price movements in the period from 2000 to 2020. The highest average annual value of silver in the observed period was recorded in 2011 in the amount of 35.12 US dollars, and the lowest in 2001 in the amount of 4.37 US dollars per triple ounce. The highest starting price of triple ounces of silver in the observed period was recorded in 2013 in the amount of 30.87 US dollars, and the lowest starting price of 4.59 US dollars in 2001 and 2002, respectively. Overall, the highest achieved annual price was recorded in 2011 in the amount of 48.70 US dollars, while the lowest annual price was in 2001 in the amount of 4.07 US dollars. Comparing the final silver prices at the end of each year with the previous one, the highest percentage of annual change in the positive sphere was recorded in 2010, where there was a change of 80.28% in the price of silver compared to the same in 2009. On the other hand, the largest negative percentage of the annual change in the price of silver was recorded in 2013, where the price of silver fell by (-) 34.89% compared to the previous year 2012.

<sup>8</sup> www.macrotrends.net (accessed September 1<sup>st</sup> 2021)



According to one study, when deciding to invest in silver, an indicator of the ratio of gold and silver can be of great help, and provide useful information about the current state of the precious metals market. Empirical analysis shows that large increases in the value of the gold-silver ratio are mainly associated with rising gold prices and falling silver prices. Conversely, a decline in the value of the gold-silver ratio is always associated with an increase in silver prices. It can be said that with the help of the value of the ratio of gold to silver, it is possible to create investment strategies using the same generator to buy or sell.<sup>9</sup>

#### 1.4. Platinum investment opportunities and its market value

In addition to gold and silver, platinum is another precious metal that is considered a good investment and a diversifier of the investment portfolio.

Platinum investment products are available in markets around the world. Before making a final investment decision, investors should definitely consider the investment product options offered to them in the market, the types that are most appropriate to their circumstances and capabilities, and the nature of professional advice that can help them in this process. As with gold and silver, platinum investment methods have the same capabilities and are based on the same operating principles, with the most popular options including investing in physical platinum, funds, and various contracts.<sup>10</sup>

Therefore, it is possible to invest in physically precious metal in the form of levers directly and through platinum accounts or platinum certificates or as coins and jewelry. Of the investments in physical platinum, the jewelry market is the second largest user of platinum, accounting for about one-third of global demand for this precious metal.<sup>11</sup> Platinum has established itself as the world's leading metal jewelry, especially supported by successful promotion in centers of growing populations such as China and India.

The market price of platinum per triple ounce is often higher than the value of gold during the period of market and political stability for the simple reason previously mentioned, which is the rarity of this precious metal and lower annual production. Also, the same reasons are the causes of high volatility of platinum, whose prices are much more volatile than the prices of gold and silver. As an example, the price of platinum fell from a peak in 2008 from \$ 2,250 to \$ 777 for one triple ounce within six months. However, the previous increase to 2,250 US dollars for one triple ounce can be explained by forced breaks in platinum production due to poor electricity supply in South Africa.<sup>12</sup> The average annual prices of triple ounces of platinum expressed in US dollars in the period from 2000 to 2020 will be shown below.

**Table 4.** Prices of platinum in the period from 2000 to 2020<sup>13</sup>

Year	Average price	Starting price	Highest annual price	Lowest annual price	Final price	Change per year (%)
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<sup>9</sup> Arendas, „Gold-Silver Ratio and Its Utilisation in Long Term Silver Investing”, 290

<sup>10</sup> Ciner, “On the long run relationship between gold and silver prices A note”, 302

<sup>11</sup> www.sbma.org.sg (accessed June 16<sup>th</sup> 2021)

<sup>12</sup> www.goldrepublic.com (accessed June 16<sup>th</sup> 2021)

<sup>13</sup> www.macrotrends.net (accessed September 1<sup>st</sup> 2021)

2000.	\$544,42	\$443,00	\$622,00	\$414,00	\$619,00	39.73%
2001.	\$528,26	\$608,00	\$637,00	\$415,00	\$480,00	-22.46%
2002.	\$539,99	\$481,00	\$607,00	\$453,00	\$598,00	24.58%
2003.	\$692,03	\$608,00	\$840,00	\$603,00	\$813,00	35.95%
2004.	\$845,83	\$815,50	\$936,00	\$767,00	\$861,00	5.90%
2005.	\$896,92	\$861,00	\$1.004,00	\$844,00	\$965,00	12.08%
2006.	\$1.142,40	\$982,00	\$1.355,00	\$982,00	\$1.118,00	15.85%
2007.	\$1.306,22	\$1.136,00	\$1.544,00	\$1.120,00	\$1.534,00	37.21%
2008.	\$1.571,04	\$1.541,00	\$2.273,00	\$763,00	\$898,00	-41.46%
2009.	\$1.205,79	\$926,00	\$1.494,00	\$844,00	\$1.461,00	62.69%
2010.	\$1.611,51	\$1.500,00	\$1.786,00	\$1.475,00	\$1.755,00	20.12%
2011.	\$1.719,03	\$1.755,00	\$1.887,00	\$1.354,00	\$1.354,00	-22.85%
2012.	\$1.550,89	\$1.406,00	\$1.729,00	\$1.390,00	\$1.527,00	12.78%
2013.	\$1.484,73	\$1.566,00	\$1.736,00	\$1.317,00	\$1.357,00	-11.13%
2014.	\$1.383,62	\$1.388,00	\$1.512,00	\$1.178,00	\$1.206,00	-11.13%
2015.	\$1.050,61	\$1.193,00	\$1.285,00	\$831,30	\$891,55	-26.07%
2016.	\$988,90	\$891,10	\$1.176,25	\$818,45	\$903,10	1.30%
2017.	\$950,49	\$936,51	\$1.028,58	\$875,40	\$937,48	3.81%
2018.	\$882,18	\$947,80	\$1.032,10	\$771,90	\$799,66	-14.70%
2019.	\$868,04	\$804,00	\$984,20	\$786,60	\$976,52	22.12%
2020.	\$893,39	\$985,00	\$1.078,44	\$596,80	\$1.078,44	10.44%

Table 4 shows historical data on platinum price movements in the period from 2000 to 2020. The highest average annual value of platinum in the observed period was recorded in 2011 in the amount of 1,719.03 US dollars, and the lowest in 2001 in the amount of \$ 528.26 US dollars per triple ounce. The highest starting price of triple ounces of platinum in the observed period was recorded in 2011 in the amount of 1,755.00 US dollars, and the lowest starting price of 443.00 US dollars in 2000. In total, the highest achieved annual price was recorded in 2008 in the amount of 2,273.00 US dollars, while the lowest annual price was in 2000 in the amount of 414.00 US dollars. Comparing the final prices of platinum at the end of each year with the previous one, the highest percentage of annual change in the positive sphere was recorded in 2009, where there was a change of 62.69% in the price of platinum compared to the same in 2008. On the other hand, the largest negative percentage of annual change in the price of platinum was recorded in 2008, where the price of platinum fell by (-) 41.46% compared to the previous year 2007.

Platinum has proven to be a good long-term investment by meeting the needs of private investors. This precious metal is most suitable for medium and long-term investors who can withstand short-term volatility and price volatility. Platinum has a low correlation with the effect of traditional assets and behaves well during periods of economic recovery. Allocation in favor of platinum improves risk-adjusted portfolio returns, including portfolios where gold is present.<sup>14</sup>

## 2. INVESTMENT PORTFOLIOS

It is often assumed that a larger share of investment portfolios are intangible assets such as stocks, bonds or money, but this is not the rule. In addition, components of an investment portfolio may include tangible investments such as real estate, art such as paintings and other collectibles, or private investment.

<sup>14</sup> www.sbma.org.sg (accessed June 16<sup>th</sup> .)

One of the prerequisites for investment ventures is adequate portfolio management, which includes an integrated, logical and meaningful investment selection process consisting of four basic activities that are continuously repeated, and they consist of:<sup>15</sup>

- o determining investment strategy and policy
- o allocation of assets
- o investment analysis
- o choice of investment

The initial and most important step of investment portfolio management is the investment strategy and policy, which sets investment objectives limited on the one hand by risk, and on the other hand by the returns on the selected investment. In this initial stage of portfolio management, the investor and his advisor, if he is involved in the investment process, sign a document which specifies in addition to the objectives and ways to achieve them.

The investment portfolio management strategy can take an active or passive form. An active strategy is achieved by investing in growth or investing in value, and the key premise is how the market can outsmart and win.

The first form, investing in growth, means investing in those objects of investment that are expected to grow more intensively than the growth of the market itself, while investing in the value of money is directed to investments that are undervalued by the market. On the other hand, if it is a passive strategy, the investor believes that the market alone functions efficiently enough, and that it cannot be outperformed.

This strategy is long-term and is based on retaining investment with the expectation that its value will increase over the long term. After the investment strategy and policy has been determined, the investor redirects his funds to selected investments, allocates capital by selected asset groups, then analyzes investments and, based on risk and return data, selects those investments that he considers optimal for the investor's investment portfolio. The investment portfolio management process never stops. Once the funds are initially invested according to a previously established plan, the real work begins with assessing the performance of the portfolio and updating the portfolio based on changes in the economic environment and the needs of investors. Authors Reilly and Brown also believe that the portfolio management process takes place in four steps:<sup>16</sup>

- o policy statement
- o examination of current and projected financial, economic, political and social conditions
- o implementation of the plan by constructing a portfolio
- o feedback

In the first step of compiling a policy statement, the focus is on the investor's short-term and long-term needs, knowledge of historical capital market data and expectations, and the policy statement itself provides the process with an objective standard. Then, the second step is to examine current and projected financial, economic, political and social conditions where the focus is on short- and medium-term expected conditions to be used in constructing a specific portfolio. The third step brings the implementation of the plan by constructing a portfolio that meets the needs of investors at the lowest levels of risk.

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<sup>15</sup> Orsag, *Investicijska analiza*, 116.

<sup>16</sup> Reilly, Brown, *Investment Analysis and Portfolio Management*, 37

Finally, the last step is feedback based on monitoring and updating the investor's needs, environmental conditions and evaluation of portfolio performance.

### **2.1. Portfolio components**

Assets that become an integral part of the portfolio are considered within asset classes. An investor or a particular financial advisor must be sure that a good and optimal combination of assets is chosen to maintain balance, which helps encourage capital growth with unavoidable limited or controlled risk. The portfolio may include stocks, bonds and alternative investments.

Shares are the most common, and therefore a fundamental component of investment portfolios. They represent part or share of company ownership.

Furthermore, bonds can be an integral part of the portfolio. If an investor buys bonds, then he is actually lending his own money to the bond issuer, which can be, for example, a government, a company or an agency.

Then, part of the portfolio may be alternative investments represented by assets whose value can grow and replicate, such as precious metals, oil or real estate.

Alternative investments also include commodity investments or investments in basic goods needed for the production of other products or services. Furthermore, cash and short-term cash equivalents may appear as one of the classes of alternative investments and include, for example, treasury bills, certificates of deposit or other short-term investments with lower levels of risk.

### **2.2. Types of portfolios**

Depending on the number of investors and the number of managers involved in the portfolio management process, so many different types of portfolios and portfolio strategies can be created. Investors may have multiple portfolios whose components may reflect different strategies or investment scenarios structured to achieve different goals or needs.

There are many types of portfolios such as hybrid portfolios, investment portfolios, aggressive stock-oriented portfolio, defensive stock-oriented portfolio, income-oriented stock portfolio, stock-oriented speculative portfolio and so on.

The hybrid portfolio approach is based on diversification between different asset classes. To build a hybrid portfolio, you need to invest your money in various forms of assets such as stocks, as well as bonds, commodities, real estate, or even art. In general, the rule is that the hybrid portfolio in its composition implies a relatively fixed percentage of stocks, bonds or alternative investments.

Minimum tracking error optimization procedures were used to create hybrid portfolios. This procedure is an extension of the classical procedure of optimization of the mean variance. The results showed that the use of a wider range of assets led to the creation of hybrid portfolios with lower tracking errors than those obtained using cash. And not only that, but the return on investment was higher than those portfolios created from a combination of real estate or cash.<sup>17</sup>

Aggressive portfolios focused on stocks in the so-called aggressive portfolio have underlying financial assets that generally take high risks in the hope that returns will be

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<sup>17</sup> Ametefe, Devaney, Stevenson, „Optimal composition of hybrid/blended real estate portfolios”, 18

just as high. The peculiarity of aggressive investors is that they are looking for start-ups or companies in general that are in the early stages of growth and have unique value.

Aggressive investors are looking for companies that have a rapid rise in earnings, but average investors have not yet discovered them. Such companies are most often found in the technology sector, but of course they can also be found in other industries. Risk management is crucial in building and maintaining an aggressive portfolio.

Then, a stock-focused defensive portfolio is based on the formation of a portfolio that most often focuses on a set of basic products used by consumers that are assumed not to experience a decline in the market. Such so-called "defense" stocks work well in the market in both bad and good times.

No matter how unfavorable the economic situation affects the economic environment at a given time, companies whose business is based on the production of products that are indispensable and crucial for everyday life, will survive in the market. As an added advantage of these types of portfolios, many of these investing firms also offer dividends, which help reduce capital losses. Defensive portfolio type is the optimal choice for most investors.

There is also a speculative portfolio that is best for investors who have a high level of tolerance for investment risk. Speculative activities may include an IPO or Initial Public Offering, which is the process of offering a private corporation's shares to the public in a new issue of shares; or they may include stocks that are rumored to be targets of takeovers. This category of investments would include those investments directed at technology or health companies that are in the process of developing a particular breakthrough product.

### **2.3. Diversification strategy in portfolios**

The goal of a diversification strategy is to maximize return by investing in different areas that would have a different response to a particular market event. There are a number of ways to diversify, and the final choice of investment portfolio components is determined by factors such as the investor's goals for the future, willingness to take risks and the investor's personality. Diversification is the most common advice to investors and regardless of the diversity of investment portfolio assets, the opinion of most investors and experts in this field is that all portfolios should contain some degree of diversification and reflect the investor's tolerance for risk, return targets, time horizon and other relevant constraints. including tax position, liquidity needs, legal situations and unique circumstances. Most investment experts agree that diversification, while not a guarantee of loss, is a key component in achieving long-term financial goals while minimizing risk.<sup>18</sup>

A specific diversification that investors can further benefit from is investing in foreign securities because they tend to be less correlated with domestic securities. For example, there is a possibility that impacts that negatively affect the U.S. economy will not affect the Japanese economy in the same way. Therefore, the possession of Japanese shares in this case gives the investor little support and protection against excessive monetary losses if there is a decline in the sphere of the American economy.

It is worth mentioning cryptocurrencies given the great rise they have experienced as a currency or speculative investments, and they can also fit into the investment portfolio

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<sup>18</sup> www.investopedia.com (pristupljeno 14.07.2021.)

and thus contribute to its diversification. The research analyzed the performance of portfolio diversification by adding Bitcoin to global industrial portfolios and the PIMCO bond index. The results showed lower dynamic correlations and significant variations in the ratios of industries and bond indices. Furthermore, dynamic correlations were found to be significantly reduced during the decline period. The results showed that investing in Bitcoin provides an effective hedging mechanism for a wide range of industry sectors and bonds, with results found to be stronger using the U.S. industry's cryptocurrency index and portfolio. These results help inform investors when deciding and adding cryptocurrencies to investment portfolios as part of the risk management and portfolio analysis process.<sup>19</sup> In addition, studies and mathematical models have shown that maintaining a well-diversified portfolio of 25 to 30 stocks provides the most cost-effective level of risk reduction<sup>20</sup>.

However, the diversification approach in creating a portfolio brings with it certain negative aspects. At the same time, the increase in the quantity of investors' portfolios means that it is necessary to invest more time or more money, to manage all portfolios. Buying and selling the shares that make up the portfolio at the same time involves more fees for transaction costs or commissions to investment professionals or other stakeholders for brokerage services. Even the logic that says that diversification reduces the risk also means that the potential returns on investment are reduced, which is confirmed by the results of the survey.

Based on the responses to the surveys, financial indicators, literacy indicators and portfolio diversification were constructed. The results of this research also showed that the lack of financial literacy can be considered the main variable that causes the lack of portfolio diversification. Equally, it was found that investors who have a certain favouritism based on familiarity, younger households, investors of lower incomes and lower levels of financial literacy tend to apply a lower level of diversification when creating a portfolio.<sup>21</sup>

#### **2.4. Modern portfolio theory**

The two key variables in making an investment decision are the return on the selected investment and the risk it entails, and the interdependence of these two factors over the investment period is explained by an investment concept called Modern Portfolio Theory. (MPT)

This financial concept was conceived by economist Harry Markowitz in 1952, and is named after Markowitz's theory, for which he received the 1990 Nobel Prize for economic contribution to the field of investment. Prior to Harry Markowitz's contribution to economics with modern portfolio theory, investing was mainly considered in terms of individual investment performance and current prices, but Markowitz pointed out that individual stock performance is not as important as the overall performance and components of the investment portfolio. The basic subject of study of this theory is the investment risk that can be viewed from two sides. Consideration of market risk or the so-called systematic risk that seeks its causes in macroeconomics, refers to inflation rates,

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<sup>19</sup> Akhtaruzzaman, Sensoyc, Corbet, "The influence of Bitcoin on portfolio diversification and design", 6

<sup>20</sup> [www.investopedia.com](http://www.investopedia.com) (pristupljeno 14.07.2021.)

<sup>21</sup> Mouna, Jarbouai, „Financial literacy and portfolio diversification: an observation from the Tunisian stock market”, 818

exchange rates, interest rates and the like; and the risk can be viewed from a specific side that arises from the unique characteristics of the investment and is valid for a specific investment or it depends on the microfactors specific to the company in which it is invested.

The basic concepts of portfolio theory became Markowitz's subject of study after being inspired by the work of John Burr Williams in which Williams suggested that the value of a stock should be equal to the present value of its future dividends.

Correlation analysis is necessarily used in portfolio selection procedures, so quantitative measures of correlation, covariance as an absolute measure of strength and correlation direction, and a relative measure - correlation coefficient are used intensively.<sup>22</sup> It is the degree of correlation that exists between the various securities in the market that plays a vital role in reducing portfolio risk; in the sense that, if the assets that make up a given portfolio are correlated, the risk that can be diversified cannot be reduced below the value of the average covariance. On the other hand, if the components of the investment portfolio are unrelated, diversifying risk can be completely eliminated and the only risk that the investor or portfolio manager must face is market risk.<sup>23</sup> Applying medium variance analysis to create an investment portfolio requires a significantly higher number of inputs to be estimated, and these include expected returns for each security, yield variances for each security and either covariance or return adjustments between each pair of securities.

When the assets being invested in have less covariance value, the more values move in opposite directions, the lower the risk of the investment portfolio. For this reason, the effective boundary is shown by a curved line rather than a straight or linear one. This implies that a diversified investment portfolio carries less risk than a portfolio consisting of a single security or group of securities moving in the same direction when market factors change. In other words, taking on more risk in an investment portfolio does not result in an equal amount of return on investment.

Of course, there are criticisms of modern portfolio theory, one of which is based on the fact that it evaluates portfolios based on variance rather than negative risk, which is an estimate of the potential loss of a security if market conditions accelerate the fall in that security. However, it is important to point out that Markowitz's model is just a tool. The most important part of portfolio theory is the assets themselves and the risk factors that the investment portfolio observer chooses. The investor must have sufficient knowledge about his property, since the model itself does not mean a guarantee of protection, or a guarantee of success. Risk factors should be carefully selected because the correlation between assets and risk factors is not always obvious.

### 3. DIVERSIFICATION EFFECTS OF PRECIOUS METALS INVESTMENTS

Numerous research papers suggest that commodities, as one of the classes of physical or tangible assets, can be the answer to many problems in today's investment activities and to the investment problems facing the world of investment.

Author Šoja (2018) emphasizes in her paper that the low correlation between commodities and bonds, stocks, but also inflation makes investments in physical goods, including precious metals, popular components in investment portfolios. Precious metals

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<sup>22</sup> Orsag, *Investicijska analiza*, 251

<sup>23</sup> Yahaya, Abubakar, Garba, „Statistical Analysis on the Advantages of Portfolio Diversification”, 105

are also considered assets that can offer protection against inflation due to their low or negative correlation with inflation and currency devaluations. For example, during inflationary pressures, the price of gold generally rises in order to balance the inflationary effects and maintain purchasing power in the market.<sup>24</sup> As an example, Erb (2020) comparing historical gold price data determine that the actual or inflation-adjusted market price of gold is currently almost as high as it was in January 1980 or August 2011. Today's high price of gold suggests that gold is an expensive asset that serves as a hedge against inflation with low expected real returns. In the past, gold price movements have been useless predictors of future inflation. In both 1980 and 2011, high real gold prices coincided with widespread views that future inflation would be significant. While such widely accepted views ultimately proved wrong, looking at today's pandemic situation, it may be different this time around, and the coming decade will prove to be a period of high inflation. Just like in 1980 and 2011, expectations of high future inflation are already embedded in the price of gold, and what will happen to the price of gold over the next decade will be largely determined by what happens to the real price of gold.<sup>25</sup>

Many practical examples show that indirect investment dominates direct investment in precious metals, ie that investing in precious metals through shares has an advantage over investing in tangible precious metals. Then, compared to platinum and silver, gold has better independent performance as an investment, and seems to provide better protection against the negative effects of inflationary pressures.

In addition, the advantages of precious metals are strongly related to the monetary conditions of the financial environment, and finally; although the benefits of adding precious metals to the investment portfolio have varied somewhat over time, they have persisted globally over the previous 34-year period.

### 3.1. Determination of the test sample

The optimal portfolio is determined by Markowitz's method or modern portfolio theory, which, among other things, includes the calculation of correlation and covariance between instruments included in the investment portfolio, as well as the calculation of expected return and portfolio risk. Certainly, for the investor, the optimal portfolio is the one whose ratio of return on investment and investment risk is the most favorable or the portfolio in which the highest possible return is achieved, with the lowest possible level of risk.

In the above examples, the positive effects of portfolio diversification are emphasized, which will be one of the goals of this scientific paper. Moreover, this diversification will be demonstrated with the help of investments in precious metals, which have proven themselves countless times as a safe haven for investors. As part of the research, a comparison of two portfolios will be presented, the first of which consists of CROBEX10 shares, and the second portfolio, in addition to the mentioned CROBEX10 shares, also contains precious metals, of which gold, silver and platinum have been separated.

For the purposes of this research work, information on CROBEX10 share prices was taken into account, which is calculated as the ratio of free float market capitalization and

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<sup>24</sup> Šoja, „Gold in Investment Portfolio from Perspective of European Investor”, 42

<sup>25</sup> Erb, Harvey, Viskanta, „Gold, the Golden Constant, and Déjà Vu”, 134,139



free float market capitalization at the base date.<sup>26</sup> Therefore, the ten shares that represent the CROBEX10 index meet the prerequisite for inclusion, which is that they are part of the CROBEX index and have the largest free float market capitalization and turnover, and in the CROBEX10 index each share participates with a maximum weight of 20%. The composition of the CROBEX10 index consists of shares represented by AD Plastik Grupa d.d. (ADPL), Adris Group d.d. (ADRS2), Arena Hospitality Group d.d. (ARNT), Atlantic Grupa d.d. (ATGR), Ericsson Nikola Tesla d.d. (ERNT), Hrvatski Telekom d.d. (HT), Končar d.d. (KOEI), OT-Optima Telekom d.d. (OPTE), Podravka d.d. (PODR) and finally Valamar Riviera d.d. (RIVP).

Also, historical data on the prices of precious metals, gold, silver and platinum were taken from the pages of the London Bullion Market Association. These price data, as well as those of CROBEX10 shares, were reviewed monthly for a period of five years from January 2016 to December 2020, while the reference prices were those that appeared on the last day in the observed period. month, or so-called "closing prices".

### 3.2. Test results

After collecting the data on the previously mentioned prices in the Excel spreadsheet, calculations followed from which it was initially necessary to calculate monthly returns for each of the observed components of the investment portfolio. The monthly return is calculated by dividing the closing price of the current month by the closing price of the previous month and subtracting those values. 1. Monthly returns allow investors to compare the returns of different assets they own in different periods of time investment decisions themselves. Table 5 below shows the monthly earnings of CROBEX10 shares in the period from January 2016 to December 2020.

**Table 5.** Monthly returns of CROBEX10 shares in the period from January 2016 to December 2020

	Monthly Return										
	A DPL	AD RS2	A RNT	A TGR	E RNT	H T	K OEI	O PTE	P ODR	R IVP	
12/2020											
0.	9,59%	0,79%	10,46%	-1,47%	0,67%	0,55%	-2,52%	6,80%	4,53%	6,09%	
11/2020											
0.	9,77%	6,16%	15,04%	11,48%	5,67%	4,94%	1,71%	6,38%	2,43%	21,30%	
10/2020											
0.	2,31%	-3,25%	-6,99%	2,52%	6,02%	1,71%	-5,65%	0,43%	1,80%	-3,36%	
9/2020											
.	-3,70%	-5,38%	7,52%	-4,80%	4,72%	4,17%	3,33%	-4,10%	5,45%	-0,42%	
8/2020											
.	4,65%	5,69%	0,00%	1,63%	1,60%	3,70%	14,29%	-16,72%	0,48%	3,91%	
7/2020											
.	-7,53%	-2,89%	2,31%	-0,81%	3,31%	8,47%	12,66%	2,81%	0,96%	10,85%	
6/2020											
.	-4,78%	-2,06%	-2,99%	0,00%	-2,42%	5,04%	1,30%	-5,00%	-0,24%	-6,52%	
5/2020											
.	6,55%	7,18%	19,64%	6,90%	8,77%	2,12%	2,68%	10,29%	0,24%	21,59%	
4/2020											
.	21,68%	3,43%	2,75%	3,57%	1,79%	1,54%	-0,44%	13,81%	12,43%	-5,81%	
3/2020											
.	-39,89%	-25,37%	-38,07%	-8,94%	-14,18%	5,52%	-	24,37%	-22,90%	27,63%	

<sup>26</sup> www.zse.hr (accessed September 8th .2021.)

2/2020						6,27					-
.	-4,57%	-6,57%	-8,33%	-8,21%	-9,06%	%	-6,30%	-28,32%	-8,39%		11,90%
1/2020											
.	3,14%	1,41%	3,78%	3,08%	2,50%	4,86%	0,00%	8,81%	-1,45%		-3,08%
12/2019											
9.	3,24%	-0,80%	1,65%	0,00%	6,06%	3,24%	-0,78%	15,22%	-0,62%		1,83%
11/2019											
9.	1,09%	0,20%	-0,55%	-2,99%	4,35%	0,89%	-0,78%	6,15%	1,46%		0,79%
10/2019											
9.	5,78%	0,61%	-1,08%	3,08%	6,75%	0,60%	-1,53%	0,00%	0,84%		1,60%
9/2019						6,03					
19.	1,17%	6,91%	1,65%	6,56%	3,49%	%	9,17%	0,00%	19,00%		1,91%
8/2019											
19.	-					1,56					
7/2019						%	4,00%	19,27%	-3,38%		1,87%
19.	7,07%	-1,07%	-4,21%	-0,81%	0,44%						
6/2019						0,00					
19.	1,08%	0,65%	4,97%	1,65%	3,17%	%	6,72%	-9,17%	2,22%		1,58%
5/2019											
19.	2,20%	5,20%	2,26%	3,42%	-3,91%	5,26		4,29%	87,50%	0,25%	2,81%
4/2019											
19.	0,00%	-2,43%	-3,28%	1,74%	5,02%	6,46		5,26%	18,52%	3,59%	3,71%
3/2019											
19.	3,70%	2,49%	7,65%	0,88%	-1,35%	0,61%	2,31%	-5,26%	5,12%		12,54%
2/2019											
19.	-4,10%	1,61%	0,00%	-5,00%	3,26%	2,19%	5,69%	78,13%	-2,62%		-0,59%
1/2019											
19.	5,78%	4,57%	-0,58%	1,69%	6,97%	5,26%	1,65%	-5,33%	0,26%		-0,88%
12/2018											
8.	-1,70%	-0,24%	0,29%	1,72%	-0,50%	1,33%	13,08%	0,00%	1,33%		-7,36%
11/2018											
8.	-2,22%	-2,57%	-2,85%	7,41%	-0,98%	2,60%	-7,76%	4,97%	3,31%		9,55%
10/2018											
8.	0,00%	0,47%	-2,23%	0,93%	-2,39%	0,65%	-6,45%	-0,62%	0,83%		10,67%
9/2018											
19.	-0,83%	-0,47%	-3,75%	0,94%	0,00%	0,00%	-6,06%	-5,26%	3,15%		-0,79%
8/2018											
19.	-6,92%	-2,06%	-2,10%	0,95%	-3,24%	1,92%	-0,75%	-6,56%	0,87%		-4,30%
7/2018											
19.	-0,51%	1,63%	-6,85%	5,53%	4,35%	0,00%	-1,48%	0,00%	1,76%		-1,00%
6/2018											
19.	-0,25%	1,42%	-3,54%	2,05%	-0,96%	3,31%	1,50%	-5,67%	5,59%		-1,48%
5/2018											
19.	-0,25%	-2,30%	0,00%	-8,88%	-5,86%	3,82%	-1,48%	-7,62%	2,88%		-1,22%
4/2018											
19.	4,79%	2,84%	-1,40%	13,23%	5,71%	4,27%	1,50%	0,96%	8,30%		0,00%
3/2018											
19.	1,08%	-0,47%	1,18%	-2,58%	-9,87%	0,00%	1,53%	2,97%	11,15%		2,24%
2/2018											
19.	-2,11%	0,95%	-3,85%	1,04%	-0,43%	0,31%	-5,07%	-14,77%	2,36%		-4,30%
1/2018											
19.	2,70%	-2,78%	-2,21%	-1,54%	-3,70%	1,51%	-1,43%	-11,24%	-5,58%		-2,78%
12/2017											
7.	9,40%	0,70%	0,44%	13,11%	0,91%	0,36%	-2,09%	-1,48%	-0,37%		-1,49%
11/2017											
7.	-0,53%	-3,38%	-4,37%	0,23%	1,60%	1,72%	1,62%	-9,67%	-10,00%		-2,69%
10/2017											
7.	1,14%	-0,67%	0,12%	3,23%	3,58%	2,72%	3,13%	-3,85%	-2,34%		-2,05%
9/2017											
19.	3,75%	3,00%	1,53%	3,87%	0,26%	1,70%	-1,86%	11,83%	3,44%		6,30%
8/2017											
19.	-2,98%	-3,98%	-4,95%	-2,07%	-5,43%	1,46%	-4,78%	-5,42%	-5,72%		-7,93%
7/2017											
19.	-2,35%	-0,66%	0,21%	0,61%	-1,27%	0,77%	1,39%	3,51%	-0,30%		6,64%
6/2017											
19.	2,92%	-2,14%	3,05%	5,66%	-1,90%	1,05%	-1,38%	0,00%	-2,37%		0,30%

6/2017										
.	-0,81%	-1,23%	-1,74%	1,36%	-3,86%	6,77%	-4,39%	-20,17%	-0,27%	9,03%
5/2017										
.	2,29%	2,93%	-2,09%	-4,39%	-1,37%	4,52%	-4,45%	-3,51%	-6,91%	-4,06%
4/2017										
.	4,37%	-0,96%	0,59%	1,38%	-3,28%	3,37%	1,46%	8,82%	-0,80%	-0,87%
3/2017										
.	-0,18%	-8,39%	-6,95%	-17,83%	-4,78%	8,95%	-5,40%	-13,27%	-15,87%	0,12%
2/2017										
.	10,75%	5,27%	0,17%	3,60%	13,03%	9,19%	1,88%	41,52%	2,44%	7,59%
1/2017										
.	2,39%	4,94%	11,60%	4,19%	8,42%	2,73%	18,45%	2,97%	7,51%	13,50%
12/2016										
6.	-0,50%	-1,30%	8,46%	-0,28%	2,03%	2,55%	0,01%	2,28%	-1,52%	-0,95%
11/2016										
6.	0,72%	3,13%	1,48%	2,14%	-1,05%	0,76%	1,46%	-0,75%	5,13%	7,05%
10/2016										
6.	1,04%	2,77%	-2,62%	-0,07%	0,97%	0,01%	0,54%	-2,93%	-3,35%	-4,48%
9/2016										
.	12,92%	7,01%	8,89%	5,70%	4,15%	1,75%	0,20%	20,80%	4,42%	18,21%
8/2016										
.	8,57%	-0,22%	-0,60%	0,69%	8,67%	2,25%	1,81%	34,52%	1,10%	8,36%
7/2016										
.	-0,48%	8,08%	22,38%	0,90%	0,66%	1,21%	4,11%	1,82%	8,72%	7,11%
6/2016										
.	2,15%	-0,99%	3,14%	-0,64%	-10,73%	0,95%	-7,59%	-2,37%	-4,84%	3,45%
5/2016										
.	9,85%	-3,35%	-1,52%	-0,11%	3,80%	2,61%	6,85%	-5,06%	5,52%	-1,76%
4/2016										
.	-3,20%	0,93%	-1,43%	-0,07%	-3,02%	0,41%	1,35%	-3,26%	2,61%	-0,37%
3/2016										
.	2,35%	10,79%	-2,18%	0,81%	12,83%	3,12%	0,21%	0,55%	2,17%	6,18%
2/2016										
.	8,37%	2,37%	0,76%	-0,62%	-0,29%	0,36%	-2,00%	-2,14%	-1,65%	1,05%

Table 5 shows the monthly yields of CROBEX10 shares in the period from January 2016 to December 2020, calculated according to historical data on the prices of CROBEX10 index components taken from the Zagreb Stock Exchange.

Also, it is necessary to determine the monthly yields of selected precious metals; gold, silver and platinum, which are shown below in Table 6.

**Table 6.** Monthly yields of gold, silver and platinum in the period from January 2016 to December 2020

	GOLD	SILVER	PLATINUM
12/2020.	7,0948%	19,5711%	9,0909%
11/2020.	-6,3395%	-6,2434%	14,9061%
10/2020.	-0,2676%	-0,4215%	-3,6199%
9/2020.	-3,5993%	-13,2541%	-4,9462%
8/2020.	-0,3842%	13,6269%	2,7624%
7/2020.	11,1306%	34,8837%	11,1794%
6/2020.	2,2792%	1,4497%	-1,3333%
5/2020.	1,5240%	14,7049%	7,5619%
4/2020.	5,8299%	10,0861%	5,5021%
3/2020.	-0,0559%	-18,9409%	-16,5327%

2/2020.	1,6191%	-3,9139%	-9,1762%
1/2020.	4,5849%	-0,8867%	0,7353%
12/2019.	3,7393%	6,3660%	6,4877%
11/2019.	-3,3621%	-6,0371%	-4,4872%
10/2019.	1,7269%	4,6363%	4,0000%
9/2019.	-2,8199%	-6,1463%	-4,1534%
8/2019.	7,0646%	11,5933%	7,5601%
7/2019.	1,3165%	8,2457%	6,7237%
6/2019.	8,7569%	5,1105%	3,4134%
5/2019.	1,0333%	-3,3700%	-11,0236%
4/2019.	-1,0113%	-0,7616%	4,5882%
3/2019.	-1,8004%	-4,5210%	-2,4110%
2/2019.	-0,3098%	-1,6174%	6,0901%
1/2019.	3,4597%	3,9444%	4,1878%
12/2018.	5,0470%	8,6407%	-2,1118%
11/2018.	0,2140%	-0,7322%	-3,4772%
10/2018.	2,3331%	0,2447%	2,3313%
9/2018.	-1,2641%	-2,3883%	2,9040%
8/2018.	-1,5152%	-5,0227%	-4,6931%
7/2018.	-2,3592%	-3,7430%	-2,3502%
6/2018.	-4,2058%	-3,1420%	-6,1742%
5/2018.	-0,5978%	1,0379%	0,2210%
4/2018.	-0,8045%	0,6143%	-3,3120%
3/2018.	0,4553%	-0,9732%	-4,3922%
2/2018.	-2,0222%	-4,5850%	-2,3928%
1/2018.	4,1867%	2,1642%	8,4324%
12/2017.	0,8436%	1,7803%	-1,5957%
11/2017.	0,7912%	-1,4863%	2,7322%
10/2017.	-1,0093%	-0,2372%	-0,5435%
9/2017.	-2,1841%	-2,7682%	-6,6937%
8/2017.	3,4870%	3,4606%	5,1173%
7/2017.	2,0366%	1,7608%	1,7354%
6/2017.	-1,8915%	-4,8527%	-2,6399%
5/2017.	-0,0197%	-0,5744%	0,1057%
4/2017.	1,7351%	-3,5991%	0,6383%
3/2017.	-0,8562%	-1,2035%	-8,6492%

2/2017.	3,5290%	5,7259%	3,8345%
1/2017.	5,8382%	6,4655%	10,3563%
12/2016.	-2,7332%	-2,5795%	-2,3913%
11/2016.	-7,3821%	-6,1374%	-5,7377%
10/2016.	-3,8185%	-8,2171%	-5,6093%
9/2016.	1,0120%	3,2551%	-1,5238%
8/2016.	-2,4404%	-6,4870%	-8,1365%
7/2016.	1,6089%	9,1503%	14,4144%
6/2016.	8,9638%	14,3213%	2,8836%
5/2016.	-5,7208%	-10,0532%	-8,8263%
4/2016.	3,9329%	16,0923%	9,1189%
3/2016.	0,1701%	4,2712%	6,2024%
2/2016.	11,0721%	4,7585%	6,1201%

The previous Table 6 shows the monthly yields of gold, silver and platinum in the period from January 2016 to December 2020 obtained from data on precious metal prices from the pages of the London Precious Metals Market.

Then, for the purpose of creating investment portfolios, the average monthly return, standard deviations and Sharpe ratios for each share shown in Table 7 were calculated from the obtained data on monthly returns.

**Table 7.** Average monthly returns, standard deviations and Sharpe ratios for CROBEX10, gold, silver and platinum

	$\mu$	$\sigma$	$\mu/\sigma$
ADPL	1,249%	7,558%	0,1652
ADRS2	0,307%	5,027%	0,0612
ARNT	0,350%	7,811%	0,0448
ATGR	0,973%	4,984%	0,1952
ERNT	0,842%	5,290%	0,1592
HT	0,521%	3,913%	0,1331
KOEI	0,006%	6,212%	0,0009
OPTE	3,207%	19,173%	0,1673
PODR	0,877%	5,759%	0,1523
RIVP	0,747%	7,928%	0,0943
GOLD	0,977%	3,969%	0,2461
SILVER	1,408%	8,456%	0,1665
PLATINUM	0,559%	6,432%	0,0870

Table 7 shows the average monthly yields ( $\mu$ ) of CROBEX10 shares and gold, silver and platinum for the mentioned period. Average monthly returns were calculated using the Excel function "AVERAGE", and it can be seen that the average monthly returns are

led by shares of AD Plastika Group (ADPL) in the amount of 1.249% and shares of Optima Telekom (OPTE) in the amount of 3.207%. Of the precious metals, silver stands out with an average monthly yield of 1.408%. Furthermore, the table also calculates the values of the standard deviation ( $\sigma$ ) which measures the dispersion of a data set relative to its mean value, and is calculated as the square root of the variance by determining the deviation of each data point relative to the mean value.<sup>27</sup> Generally speaking, in order to observe the effect of standard deviation in this case, volatile stocks with high values of standard deviation and, in contrast, stable "blue chip" stocks with low values of standard deviation can be taken as an example. The larger the standard deviation of securities, the greater the variance between each price and the mean, which indicates a larger price range and of course, the standard deviation helps to measure risk and market volatility, and thus predict future price trends. It should be noted that the OPTE share had by far the highest value of the standard deviation in the amount of 19.173%. The last column of the table shows the ratio of average monthly yields and standard deviations, which can be called the Sharpe ratio, although the risk-free rate values are excluded from the calculation, which are neglected due to the small amount in this case. In general, the Sharpe ratio is the average income earned above the risk-free rate per unit of volatility or total risk. According to modern portfolio theory, adding assets to a diverse portfolio with low correlations can reduce portfolio risk without sacrificing returns, ie adding diversification should increase the Sharpe ratio compared to similar portfolios with a lower level of diversification.<sup>28</sup> The highest value of the Sharpe ratio in Table 7 was gold in the amount of 0.2461.

For the purposes of creating the portfolio, a covariance matrix had to be created. The covariance shows how much the two variables change together, and becomes more positive for each pair of values that differ from their mean values in the same direction, and becomes more negative for each pair of values that differs from their mean values in opposite directions.<sup>29</sup> In the continuation of the work in Table 8, the matrix of variances and covariances composed of CROBEX10, gold, silver and platinum shares is presented.

**Table 8.** Matrix of variances and covariances of CROBEX10 shares, gold, silver and platinum

	ADPL	ADRS2	ARNT	ATGR	ERNT	HT	KOEI	OPTE	PODR	RIVP	Au	Ag	Pt
ADPL	<b>0,006</b>	0,003	0,004	0,002	0,002	0,001	0,002	0,004	0,002	0,003	0,000	0,002	0,002
ADRS2	0,003	<b>0,002</b>	0,003	0,001	0,002	0,001	0,002	0,003	0,002	0,003	0,000	0,001	0,002
ARNT	0,004	0,003	<b>0,006</b>	0,001	0,002	0,001	0,003	0,004	0,002	0,004	0,000	0,003	0,003
ATGR	0,002	0,001	0,001	<b>0,002</b>	0,001	0,001	0,001	0,002	0,001	0,002	0,000	0,001	0,001
ERNT	0,002	0,002	0,002	0,001	<b>0,003</b>	0,001	0,002	0,003	0,001	0,002	0,000	0,001	0,001
HT	0,001	0,001	0,001	0,001	0,001	<b>0,002</b>	0,001	0,003	0,001	0,001	0,000	0,000	0,001
KOEI	0,002	0,002	0,003	0,001	0,002	0,001	<b>0,004</b>	0,002	0,002	0,002	0,000	0,001	0,001
OPTE	0,004	0,003	0,004	0,002	0,003	0,003	0,002	<b>0,036</b>	0,002	0,003	0,002	0,002	0,002
PODR	0,002	0,002	0,002	0,001	0,001	0,001	0,002	0,002	<b>0,003</b>	0,002	0,000	0,001	0,001

<sup>27</sup> www.investopedia.com (accessed September 08th .2021.)

<sup>28</sup> Ibidem (accessed September 8th 2021.)

<sup>29</sup> www.racunala.ttf.unizg.hr (accessed September 8th 2021.)

RIVP	0,003	0,003	0,004	0,002	0,002	0,001	0,002	0,003	0,002	<b>0,006</b>	0,000	0,001	0,002
Au	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,000	<b>0,002</b>	0,002	0,001
Ag	0,002	0,001	0,003	0,001	0,001	0,000	0,001	0,002	0,001	0,001	0,002	<b>0,007</b>	0,004
Pt	0,002	0,002	0,003	0,001	0,001	0,001	0,001	0,002	0,001	0,002	0,001	0,004	<b>0,004</b>

Table 8 shows the matrix of variances and covariances whose values were obtained using the Excel function "COVAR", and the matrix itself is needed to calculate the weight shares of portfolio components and includes ten stocks from the CROBEX10 index and gold, silver and platinum. The diagonal elements of the matrix show the variances of the observed variables, while the elements outside the diagonal contain covariances between all possible pairs of observed variables.

The next step in the research, after collecting the necessary data, was to create the investment portfolios themselves. The portfolios shown in Table 9 contain CROBEX10 index shares.

**Tablica 9.** CROBEX10 index stock portfolios

Portfolios A	1. Equal WT.	2. Max Ret.	3. Min St. Dev.	4. Max SR
Constraining variable	None	at $\sigma \leq$	at $\mu =$	None
Value of Constraint	N/a	3,913%	3,207%	N/A
	Portfolio Weights			
ADPL	10%	5%	0%	14%
ADRS2	10%	0%	0%	0%
ARNT	10%	0%	0%	0%
ATGR	10%	34%	0%	49%
ERNT	10%	16%	0%	11%
HT	10%	29%	0%	0%
KOEI	10%	0%	0%	0%
OPTE	10%	5%	100%	13%
PODR	10%	11%	0%	13%
RIVP	10%	0%	0%	0%
SUM of Weights	100%	100%	100%	100%
$\mu$	0,9079%	0,9315%	3,2071%	1,2697%
$\sigma$	4,9748%	3,9131%	19,0095%	5,0707%
$\mu/\sigma$	0,1825	0,2380	0,1687	0,2504

Table 9 shows four portfolios created from CROBEX10 shares using the Excel function called "Excel Solver", and in all portfolios there is a restriction on the prohibition of taking short positions, or so-called "shortselling". This restriction changes the portfolios so that in these cases, if the share in the portfolio marked with a negative

sign became equal, it becomes equal to zero, or such a component of the portfolio in the adjusted portfolio is 0%. The first portfolio was created with equally distributed stock weights, each share accounted for 10% of the portfolio, with a yield of 0.9079%, a standard deviation of 4.9748% and a Sharpe ratio of 0.1825. For further calculation, an investment portfolio was generated with the help of Excel solver in which the goal was to maximize the return, and therefore the Excel solver set as one of the restrictions that the standard deviation of all portfolio components must be less than or equal to the lowest value. case was from HT shares and amounted to 3.913%. Under such conditions, the investment portfolio was achieved with yields of 0.9315%, standard deviation 3.9131% and Sharpe's ratio of 0.2380. From the above we can see the effect of diversification in which for the minimum standard deviation from HT shares achieved a higher return on investment by diversifying the portfolio in the amount of 0.9315%, than this return would be if invested only in HT shares followed by the same value standard deviations, but the return was lower at 0.521%. The third portfolio was created with the aim of minimizing the standard deviation, and the OPTE share with the highest return of 3.207% was selected as a constraint with the aim of achieving a return equal to or greater than the above. It turned out that for such a portfolio, the investor should invest all the funds in the specified share, and in this case, diversification would not contribute to higher portfolio returns. Such a portfolio achieves the highest yield of 3.2071% and by far the largest standard deviation of 19.0095% with the lowest Sharpe ratio value of 0.1687. The returns of such a portfolio would be as high as possible, but diversification does not exist since all funds are directed to one component of the portfolio, which carries a high risk, as seen with high values of standard deviation and low Sharpe ratio. The last portfolio was created with the aim of achieving the highest possible value of the Sharpe ratio. A portfolio with yields of 1.2697%, a standard deviation of 5.0707% and a Sharpe ratio of 0.2504 was achieved. Such a portfolio would consist of only five stocks in the ratios shown in Table 9.

After creating a portfolio consisting only of CROBEX10 index shares, Table 10 shows the investment portfolios which, in addition to CROBEX10 index shares, also include precious metals, gold, silver and platinum.

**Table 10.** Portfolios of CROBEX10, gold, silver and platinum index stocks

Portfolios B				
	1. Equal WT.	2. MaxRet.	3. Min Dev.	4. St. Max SR
Constraining variable	None	at $\sigma \leq$	at $\mu =$	None
Value of Constraint	N/a	3,913%	3,207%	N/A
Portfolio Weights				
ADPL	8%	12%	0%	3%
ADRS2	8%	0%	0%	0%
ARNT	8%	0%	0%	0%
ATGR	8%	19%	0%	12%
ERNT	8%	0%	0%	12%
HT	8%	0%	0%	7%



KOEI	8%	0%	0%	0%
OPTE	8%	10%	100%	2%
PODR	8%	7%	0%	11%
RIVP	8%	0%	0%	0%
GOLD	8%	51%	0%	52%
SILVER	8%	1%	0%	0%
PLATINUM	8%	0%	0%	0%
SUM of Weights	100%	100%	100%	100%
$\mu$	0,9249%	1,2323%	3,2071%	0,9732%
$\sigma$	4,4526%	3,9130%	19,0095%	2,8835%
$\mu/\sigma$	0,2077	0,3149	0,1687	0,3375

Table 10 shows the portfolios which, in addition to shares of the CROBEX10 index, include precious metals, gold, silver and platinum, and all portfolios are limited to not occupying short positions, ie the previously mentioned "shortselling". The first portfolio created consists of 13 components, which consists of ten CROBEX10 shares and gold, silver and platinum, and in this portfolio each component participates with equal weight in the total portfolio in the amount of 7.6923%, ie approximately 8%. By creating an equally weighted investment portfolio, yields of 0.9249%, a standard deviation of 4.4526%, and a Sharpe ratio of 0.2077 were achieved. Also, as in the previous table 7, for further calculation, an investment portfolio was formed with the help of Excel solver in which the goal was to maximize the return, and in Excel solver the limit is set that the standard deviation of portfolio components must be less than or equal to the lowest deviation component which in this case was of HT shares and amounted to 3.913%. Under such conditions, a portfolio with yields of 1.2323%, a standard deviation of 3.9130% and a Sharpe ratio of 0.3149 was achieved. This portfolio therefore consists of 51% by weight of gold and 1% by weight of silver. If we compare the same type of portfolio from Table 9 with this data, a large change in the redistribution of weight shares of portfolio components can be noticed, and this proves that precious metals serve as good diversifiers in investment portfolios. Also, the third portfolio was created with the aim of minimizing the standard deviation, and as in Table 9, the OPTE share was selected as the limit, which achieved the highest returns of 3.207%, with the aim of achieving returns equal to or greater than the above. As in Table 9, after the introduction of the already mentioned restriction that does not allow "shortselling", it turned out that for such a portfolio the investor should invest all funds in the specified share, and in this case diversification would not contribute to higher portfolio returns. The highest yield is 3.2071% and the standard deviation is 19.0095% with a Sharpe ratio of 0.1687. As previously mentioned, the returns of such a portfolio would be potentially higher, but diversification does not exist as all funds are directed to OPTE shares which carries a high risk as confirmed by high values of standard deviation and low Sharpe ratio. Finally, in the fourth type of portfolio, which had the task of maximizing the Sharpe ratio, the return on investment was 0.9732%, followed by the standard deviation of 2.8835%, which is the most favorable, ie the lowest if compared to the previous three types of investment. portfolio and also, a Sharpe ratio value of 0.3375 was achieved which is the

highest and most favorable value compared to previous Sharpe ratio results. This portfolio therefore consists of as much as 52% by weight of gold and if we compare the same type of portfolio from Table 9 with this data, we can also notice a big change in the redistribution of weight shares of investment portfolio components and this once again confirms how precious metals serve as good diversifiers in investment portfolios.

The portfolios created in Tables 9 and 10 were calculated using Excel solvers, with the aim of proving the hypothesis that the inclusion of precious metals gold, silver and platinum will contribute to portfolio diversification to generate higher returns while accompanied by lower risk values. In Table 11, in order to establish the hypothesis, the values of yield, standard deviation and Sharpe ratio in both observed cases will be shown in parallel.

**Table 11.** Comparison of yield values, standard deviation and Sharpe portfolio ratios A and B

		Portfolios		high $\mu$ ; low $\sigma$ ; high $\mu/\sigma$
		A	B	
1. Equally Wt.Portfolio	$\mu$	0,9079%	0,9249%	Portfolio B
	$\sigma$	4,9748%	4,4526%	Portfolio B
	$\mu/\sigma$	0,182504	0,207715	Portfolio B
2. Max. Ret. Portfolio	$\mu$	0,9315%	1,2323%	Portfolio B
	$\sigma$	3,9131%	3,9130%	Portfolio B
	$\mu/\sigma$	0,238039	0,314911	Portfolio B
3. Min. St. Dev. Portfolio	$\mu$	3,2071%	3,2071%	Portfolio A=PortfolioB
	$\sigma$	19,0095%	19,0095%	Portfolio A=PortfolioB
	$\mu/\sigma$	0,168711	0,168711	Portfolio A=PortfolioB
4. Max. SR Portfolio	$\mu$	1,2697%	0,9732%	Portfolio A
	$\sigma$	5,0707%	2,8835%	Portfolio B
	$\mu/\sigma$	0,250391	0,337498	Portfolio B

Table 11 shows in parallel the values of yield, standard deviation and Sharpe ratio in both observed cases; case A in which only CROBEX10 index shares are included and case B which in addition to CROBEX10 shares includes precious metals, gold, silver and platinum. Comparing the portfolios of both cases created with the same weight share of components in the portfolios, it can be noticed that the inclusion of precious metals in the portfolio in case B achieved higher yields of 0.9249%, which is higher than the yields achieved in case A of 0.9079%. For the same type of portfolio, the standard deviation was lower in the case of portfolio B and amounted to 4.4526%, while the same in case A amounted to 4.9748%. A lower standard deviation is preferable because it means smaller deviations, and thus less risk, and it has been proven that the inclusion of precious metals in the portfolio reduces the same. Equally, the risk measure in the form of Sharpe's ratio showed that it was more favorable, ie a higher value in case B where precious metals were included in the portfolio and amounted to 0.20771593, as opposed to portfolio A where Sharpe's ratio was 0.18250476. It can be concluded that Portfolio B performed better than Portfolio A in terms of yields, standard deviation and Sharpe ratio. In the same way, it resulted in the creation of a portfolio aimed at maximizing returns, and in

this case, Port B surpassed the performance of Portfolio A in terms of higher yields of 1.2323%, slightly lower standard deviations of 3.9130%, and higher values Sharpe ratio of 0.31491186. The third type of portfolio in order to minimize the standard deviation resulted in equal values in the case of portfolio A and in the case of portfolio B because the mentioned restriction was introduced which prevents "shortselling", and the data cannot be compared in this case. Finally, a fourth type of portfolio was created with the goal of maximizing Sharpe's ratio. Although the returns of portfolio B (0.9732%) in this case were slightly lower than the value of the return of portfolio A (1.2697%), it can be said that in this case the hypothesis that precious metals enhance portfolio diversification has been proven. significantly lower standard deviation of 2.8835%, and higher Sharpe ratio values of 0.33749882.

## CONCLUSION

In today's globalized world, changes in financial markets are generally very common. Precisely because of the frequency of changes and globalization, some events are very difficult to assess, making them more difficult, among other things, in the processes of trade and investment. In such an environment, there is a greater need for security, which in the investment segment, investors find in general in diversification, but also specifically in investing in precious metals. Before trading or investing, investors should carefully consider and determine their own financial position and willingness to take risks in order to determine if a particular style of trading or investing is appropriate for them. Each investor has the highest possible returns with the lowest possible level of risk for the set goal. In order to achieve this goal, investors often turn to investing in precious metals. Throughout history, precious metals have always had a notable reputation and specific roles such as the role of global currencies, objects of trade, sometimes the role of financial assets and, of course, jewelry. Possession of precious metals can act as a hedge against inflation, can serve to diversify good investment portfolios or as a financial cover in difficult times. Taking into account the current state of the world economy, precious metals attract investors and are of interest as a long-term investment object with high efficiency and reliability compared to other investment assets. Investors around the world are investing in precious metals primarily because there is a mismatch between supply and demand. The demand for precious metals is much higher than the supply of precious metals because their quantities are limited and rare. This has led to a constant rise in the prices of precious metals over the years and therefore, precious metals often appear as components of the investment portfolios of investors around the world. Of course, one of the assumptions for effective investment is that investors should diversify their investment portfolio, and precious metals for the above reasons can be of great benefit. Therefore, it is certainly not recommended that an investor invests all his / her available funds in only one investment opportunity. This would mean that the investor would become too dependent on one investment, which is extremely risky. In this paper, through a practical example of creating two types of investment portfolios, one type of portfolio does not include precious metals and the other type of portfolio that includes, it is proven that precious metals can contribute to diversification of investment portfolios and provide the investor and higher Sharpe ratio values.

Finally, the advice to investors, which is generally known, and symbolically reads: "Do not put all the eggs in one basket." It is necessary to allocate own investments in order to create a more robust and less volatile investment portfolio, and precious metals

can serve as a tool to achieve this goal as an investment option and a kind of risk protection.

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