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Development and Perspective of Gold and Silver Jewelry Imports to Slovakia Considering the Impact of the COVID-19 Pandemic

Desenvolvimento e Perspetivas das Importações de Joias de Ouro e Prata para a Eslováquia Considerando o Impacto da Pandemia da COVID-19

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Abstract

This study focuses on gold and silver jewelry import to Slovakia between the years 2010–2022 for hallmarking according to the country of origin. The aim of the research was to analyze and predict the import of gold and silver jewelry to Slovakia using statistical methods, namely the correlation coefficient and time series analysis. Using the correlation coefficient, we determined the relationship or degree of relation between selected countries of origin based on the amount of gold and silver jewelry (in kg) imported to Slovakia for hallmarking. We obtained an estimate of the future development trend of gold and silver imports into the domestic market from abroad using the time series method, particularly regression analysis and Holt-Winterson methods. It was found that the import of gold jewelry to Slovakia from the studied countries has an upward trend and, conversely, the import of silver jewelry has a downward trend.

Keywords: Hallmarking; Correlation coefficient; Holt-Winterson method

Resumo

Este estudo centra-se na importação de joias de ouro e prata para a Eslováquia entre os anos 2010–2022 para marcação de acordo com o país de origem. O objetivo da investigação foi analisar e prever a importação de joias de ouro e prata para a Eslováquia utilizando métodos estatísticos, nomeadamente o coeficiente de correlação e a análise de séries temporais. Utilizando o coeficiente de correlação, determinamos a relação ou grau de relação entre os países de origem selecionados com base na quantidade de joias de ouro e prata (em kg) importadas para a Eslováquia para punção. Obtivemos uma estimativa da tendência de desenvolvimento futuro das importações de ouro e prata do exterior para o mercado interno usando o método de séries temporais, particularmente análise de regressão e métodos de Holt-Winterson. Verificou-se que a importação de jóias de ouro para a Eslováquia a partir dos países estudados tem uma tendência ascendente e, inversamente, a importação de jóias de prata tem uma tendência decrescente.

Palavras-chave: Marcação; Coeficiente de correlação; Método Holt-Winterson

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1 Introduction

Precious metals have been highly valued since time immemorial and this is still the case today. Ever since mankind encountered precious metals, especially gold and silver, they have always been fascinated by these metals. Over time, as people figured out how easy it was to process, it gained a strong foothold in the business world and in culture. Slovakia was also known for gold and silver mining, especially, in the Middle Ages.

1.1 History of Ore Mining in Slovakia

The territory of today's Slovakia represented a relatively small part of the Kingdom of Hungary in the Middle Ages. However, due to its exceptional concentration of precious and non-ferrous metal deposits and mining, it played a key role in its economy. In the Middle Ages, there were two important mining regions in Slovakia with historical mining: Central Slovakia and East Slovakia. The Central Slovak mining region was documented sooner, it was richer and in most respects even more important. It first included six, later seven towns: Banská Štiavnica, Banská Bystrica, Kremnica, Pukanec, Ľubietová, Nová Baňa and from the first quarter of the 15th century also Banská Belá. The East Slovak, i.e. "Upper Hungarian" mining towns were Rožňava, Gelnica, Smolník, Spišská Nová Ves and Jasov in the historical regions of Spiš and Gemer.

Metal mining, especially gold, silver and copper, was one of the mainstays of the Hungarian economy. It provided a valuable item for foreign trade because, apart from them, the agricultural country had little to offer in growing international trade. Precious metals exported in the form of coins or by weight functioned as currency, so this relationship is also characterized as a passive trade balance. Specific written documents on mining and the metal trade date back to the existence of the medieval Kingdom of Hungary. The first mention from the 11th century relates to the export of silver and silver coins from Hungary. They appeared on foreign markets in the Baltic (Germany, Poland, Gotland) and the Black Sea region of the Danube estuary (Kievan Rus / Pereyaslav). Foreign buyers were already coming to the country at that time to stock up on it. It is believed that Hungarian silver was involved in the work of the Kremnica and Vienna mints. At the end of the 12th century, the invention of pumping equipment secured for a long time the deepening shafts from flooding and thus protected at least 3-4 generations from the first crises of deep mining. Throughout the 13th century, there is evidence that point to Venice as a very important consumer of Hungarian silver, along with domestic evidence documenting the intensive development of mining.

We can state that before the discovery of America in the 14th and 15th century, the territory of present-day Slovakia was one of the leading producers of precious metals in Europe, and the centers of Slovak mining, especially Banská Štiavnica and Kremnica, were very well known throughout medieval Europe. Slovak mining became famous for the second time in the 18th century, especially with the development of mining technology and mining education. The Mining Academy, founded in 1762 in Banská Štiavnica, was one of the first mining universities in the world (Knésl & Knéslová 2006).

1.2 Current Situation in Slovakia

Despite the historical tradition in mining and processing of ore raw materials, the Slovak Republic is no longer the country with a developed mining industry. This is confirmed by the currently used United Nations Trade and Development Method (UNCTAD), which classifies countries with a developed mining industry in which the share of mining and quarrying in gross domestic product (GDP) is higher than 25% (Blišťan et al. 2009). Compared to the world, the production of selected mineral commodities in Slovakia in recent years, with the exception of magnesite, accounts for only 0.01 to 0.8% of global production, which means that the share of mining, especially ore, in GDP is relatively stable, but low.

In accordance with the metallogenetic zoning by Ilavský and Sattran (1980), there are 25 ore ditches in Slovakia (Figure 1). At present, some of them cannot be considered promising in terms of the possible presence of gold mineralization for environmental reasons (High Tatras National Park) or because there is not enough relevant evidence of gold in them (mountains: Malá Fatra, Veľká Fatra, Žiar, Levočské vrchy, Vihorlat).

Due to the high geological exploration of the territory of Slovakia, the discovery of new deposits suitable for use in the current market conditions is unlikely. The only solution would be to reopen subdued mining plants, but in many cases it would be very costly. Taking into account the high production costs of mining and processing of gold and silver raw materials, mining is economical only if the current high prices of precious and non-ferrous metals are maintained on world stock exchanges (Blišťan et al. 2009).

A brief overview of the prospecting possibilities of ore districts (gold and silver) of the Slovak Republic clearly shows that in Slovakia, despite many years of gold and silver mining and considerable depletion of known deposits, there is still the prospect of finding economically usable ore deposit accumulations. Knésl and Knéslová (2006) assumed that the world price of gold would be above USD 500 per ounce in the coming years, which could raise the need

to re-evaluate some unextracted parts of the Slovak vein deposits in terms of the content of other metals, especially silver, copper or antimony. The price of gold has increased significantly, but mining of precious metals in Slovakia has not been resumed much yet.

1.3 World Gold and Silver Mining

The five largest gold producers in the world include China (representing 11% of world production), Russia, Australia, the USA and Canada. According to data published by the World Gold Council (2021), global gold mine production in 2020 was 3,478.1 tons (122.7 million ounces), which is a slight decline for the second year in a row in recent years which it was constantly growing. The pandemic has apparently contributed to this slowdown over the past year, but we may also see the consequences of ever-shrinking survey budgets. This raises the question of whether the peak of gold has finally arrived. In addition to South Africa's departure from the top 10, the list has undergone several other minor changes since 2019, such as Peru also dropped out of the top 10, freeing up space for Uzbekistan, while Brazil advanced several places. Ghana remains the only African country to appear in the top 10. South Africa was also a world leader in gold production at the time, digging more than 1,000 tons in 1970, but its amount has declined rapidly since then. Last year, it completely dropped from the list of the 10 largest gold producers (World Gold Council 2021).

Furthermore, the five largest silver producers in the world include Mexico, Peru, China, Russia and Poland. In 2021, Mexico was again the world leader in silver production. Global silver production increased slightly to 24,000 metric tons (MT) during this period due to a return to production in key countries following outages during the COVID pandemic. Estimated global silver production in 2019 was approximately 27,000 metric tons. According to the Silver Institute (2021), global mine production fell by 1.3% in 2019 for the fourth consecutive year, and primary silver production fell by 3.8%. The largest decline was in Peru, followed by Mexico and Indonesia. However, some countries have recorded an increase in production, such as Argentina, Australia and the United States.

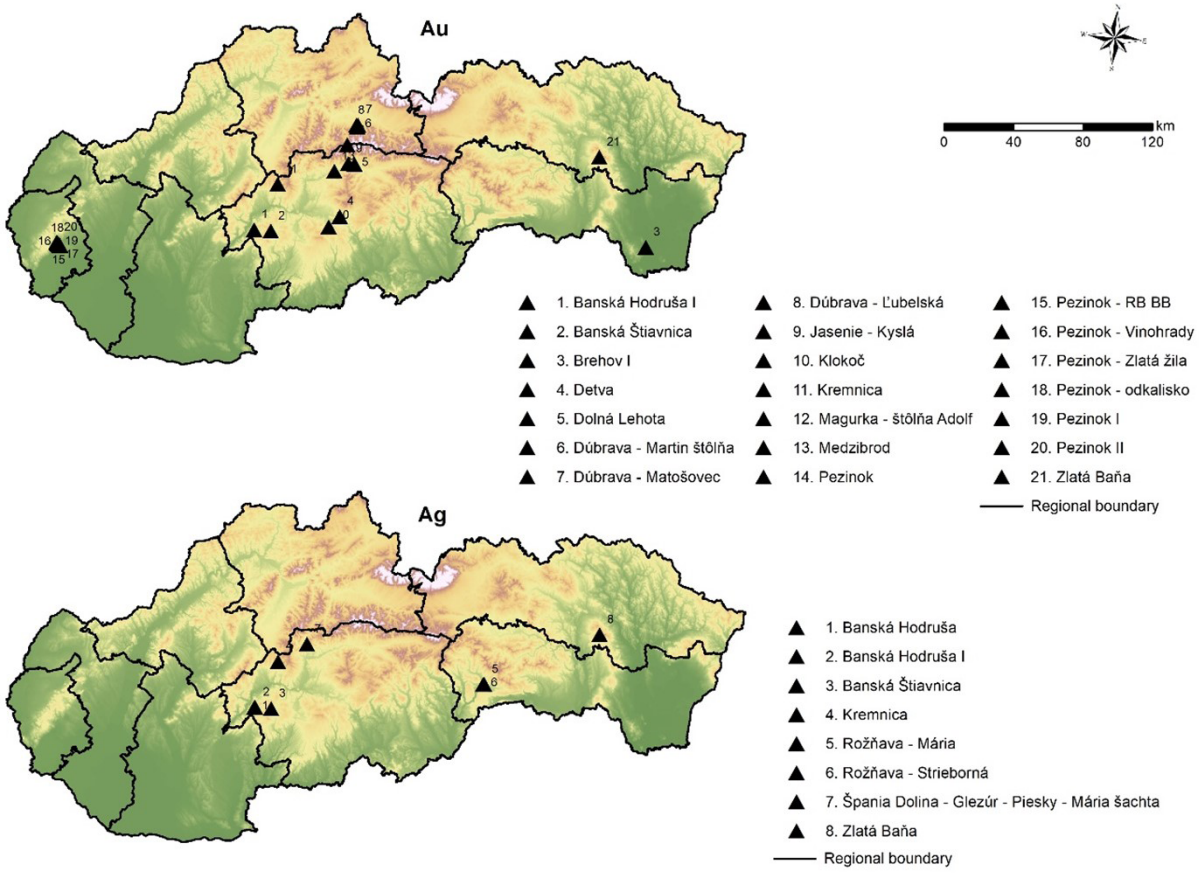

Figure 1 Mining of gold (au) and silver (ag) in Slovakia.

1.4 Geopolitics, Trade and Demand

Since the collapse of the Bretton Woods Agreement in 1971-1973, the official role of gold in the international monetary system has ended. Following the peg of the US dollar to gold, there have been large fluctuations in gold prices. Since the beginning of 2000, precious metal prices have appreciated and prices have risen further. Under the circumstances, forecasting the price of these commodities has important consequences not only in monetary but also in economic (Levin & Wright 2006).

The world price of gold reflects the economic stability of international relations, but also depends on the state of the raw material base and other factors affecting the useful value of gold directly and indirectly (Slavkovský 1999). In fact, it is not the world price, but the prices of individual exchanges, which are very significant from a global point of view of the gold trade. It is mainly the London Metal Exchange (LME), as well as quotations on the American continent on the Commodity Metals Exchange (COMEX), but also on other exchanges, but nevertheless a large part of the gold trade is carried out on the basis of long-term contracts between producers and customers in the form of so-called producer prices. These prices react to the change in stock prices only subsequently, i. e. in periods of price growth, they favor the customer and the producer's price drop, but they do not react to accidental or short-term fluctuations in stock prices. Fluctuations in demand and inflexibility of supply are among the main causes of fluctuations in the price of gold, but they can also be significantly affected by monetary factors and crisis situations in the world (Baláž & Hanas 2006). The USD has long been a decisive position in the world economy, so the stock market and producer price of gold is mostly quoted in that currency (Capie et al. 2004).

The price of gold is also specific in that it is sensitive to political developments in the world (terrorist attacks, wars, etc.), extreme weather events (natural disasters), as well as speculative buying and selling on stock exchanges. Raw material prices, especially gold and oil, usually respond to uncertainties with sharp increases. Gold also provides protection against inflation (Ranson 2005), as its price generally rises faster than inflation. At a time of high or rising inflation, gold becomes a guarantee of value, and the ensuing increased demand for it pushes its price up. Prices of gold and silver, as well as other metals (platinum, copper and zinc) have reached the highest level in the last 25 years, i.e. are the highest in history ever. The average price for 2021 was USD 1798.61 per ounce, i.e. troy ounce, which is a traditional unit of weight for gold, platinum and other precious metals. The name comes from the Middle Ages in the French city of Troyes and the average price of silver (London PM Fix) per year 2021 was $ 25.0366 per ounce (https://www.kitco.com/).

The reason for the high price of gold and silver is the growing consumption, especially in the developing countries of Asia and Russia, as well as the fact that investors buy gold to protect themselves from rising inflation and falling USD. The market price of gold is also increased by speculation that several central banks - especially Asian and European - will invest in gold at the expense of the USD. It is natural that the rapidly growing demand for gold cannot be immediately covered only by increasing the mining of existing deposits, and the opening of mining in new localities is relatively long-term. The price of raw materials is also rising due to the increased interest of investors in trading with them or for investment growth also in areas copying market developments. The fall in prices could result from production above consumption or when the growth of the world economy weakens. The development of the price of gold as well as other raw materials is cyclical and analysts estimate that the current upward trend will continue (Baláž & Hanas 2006).

However, current gold prices take into account not only immediate supply and demand, but also expectations of future supply and demand. According to experts, the less information available, the greater the price volatility. It is an agreement between market participants to buy and sell gold at a fixed price or to maintain market conditions so that the price remains at a certain level by managing supply and demand.

Today, similarly as before, gold is traded in large and small amounts. Trading has remained the same for almost a hundred years, the minimum amount of one trade is 1000 ounces, about 31.10 kg of pure metal in the form of 12.5 kilogram gold bars. Twice a day, the world's major gold traders, mostly bank representatives in London, meet at Swithin's Lane in order to conjunct with the whole world and unite world supply and demand and find an immediate equilibrium price. At this reference price, they will then carry out a huge number of settled pending transactions around the world, in line, thus affecting the global ongoing all-day gold market for the next few hours, until a similar ceremony called "gold fixing". A very important part of the price of gold is the premium, the surcharge of the selling trader. It usually ranges from 2 to 4% to several tens. For the smallest ingots and gold coins, this surcharge can reach up to 80%. The principle and method have not changed for more than a hundred years. One of the few changes is the use of modern communication technologies and tools. Today, gold is traded in many places, the most important being Zurich, Paris, New York, Hong Kong, Mumbai,

Shanghai and Dubai. The most significant event in recent years has been the legalization of gold trade and imports in India and China.

Demand for both gold and silver is influenced by three main areas - jewelry, industry and investment. In particular, investment in gold (trading funds, gold bars and coins) has grown significantly in recent years and has been a major factor influencing its price movements. But in terms of the amount of gold, the greatest demand is in the production of jewelry, especially in the economically developing countries of Asia. Demand in the industrial sector (electrical engineering, dental prostheses, etc.) in comparison with previous applications is not so significant and is growing mainly in East Asia (Japan, Singapore, South Korea, China) and the US (Baláž & Hanas 2006).

Import of gold to Slovakia can be in the form of investment gold (gold bars and coins) or in the form of physical gold - jewelry. Investment gold in Slovakia has no tradition in recent decades although in the past its role was more important. To some extent, this is also due to a lack of financial education in the previous regime. In other countries, investment gold has long been perceived as a regular feature of almost every client's portfolio.

In this paper, the aim is the analysis of imports of physical gold and silver, i.e. gold and silver jewelry from selected countries (Italy, Turkey, Germany, Hungary, Poland, Czechia and Austria) to Slovakia for the period 2010 to 2022 as well as prediction of their imports. Similar research was conducted by Sakemoto (2018), Demiralay and Ulusoy (2014), Mutafoglu et al. (2012), Dunis and Nathani (2007), who also studied the development, but focused more on the price of gold and silver using the regression analysis. Moreover, Spearman correlation coefficient was also used in the studies by Cerny et al. (2021), Chinchilla et al. (2021), Kopacz et al. (2020) or Podhorodecka (2018).

2 Methods

Gold (Au) has unique physicochemical properties. It has excellent electrical conductivity, it is resistant to alkalis, acids and their salts, oxygen and hydrogen sulfide. It dissolves easily in mercury. During magmatic differentiation, gold is concentrated in late magmatic products. Gold occurs in several modifications - such as pure metal, a natural alloy with silver and other metals, as well as in the form of tellurides. The quality (purity) of gold is given in carats or in shares per 1,000 (24 k pure 24/24 = 1,000 / 1,000, 14 k 14/24 gold = 583 / 1,000) (Kúšik et al. 2017). Compared to other metals, it is almost chemically non-reactive, it does not lose its luster under atmospheric influences and it is soft and heavy. With the exception of jewelry production, where most of its production is directed, it is used in practice to a very limited extent (electronics, dental prostheses, etc.) (Baláž & Hanas 2006).

Silver (Ag) is white, relatively soft wrought metal and is the best metal conductor of heat and electricity, alloying many metals. About 65% of the world's silver reserves are found in copper and polymetallic deposits of various types, 35% of the reserves are found in vein deposits, where silver is the main utility component. Silver is consumed the most by industrial applications, especially electronics and electrical engineering, where consumption is on the rise. The use of silver as a precious metal in jewelery and in the manufacture of goods from silver is in decline and a further decline is expected in the future. A slight decrease in consumption was recorded in the photographic industry, mainly due to the boom in digital photography. Silver is also used in the production of alloys (5%) and coinage (3%). Another use is in water purification, production of batteries, mirrors, special reflective surfaces, catalysts, in nuclear energy in the production of control rods for water reactors, in medicine, etc. Silver consumption is covered by imports (Kúšik et al. 2017).

As we have already mentioned, the subject of the research was gold and silver jewelry imported to Slovakia in the years 2010–2022 for hallmarking according to countries of origin. Gold and silver jewelry from various countries, such as China, Hong Kong, Romania, Great Britain, Thailand, etc. are also being imported to Slovakia, but in this article we deal with only the seven largest importers of gold and silver jewelry - Italy, Turkey, Germany, Hungary, Poland, Czechia and Austria.

The materials of the Assay Office of the Slovak Republic were used for the research. We determined the degree of relationship between selected countries of origin with respect to the amount of gold and silver jewelry (in kg) imported to Slovakia for hallmarking.

> **H1.** There is a link between the selected countries due to the amount of gold and silver jewelry imported to Slovakia. We verified the validity of the research hypothesis using selected statistical methods, namely the correlation coefficient.

Given that the assumption of a normal distribution, such as the degree of statistical dependence, we used the Spearman rank correlation coefficient R, which is defined in Equation 1:

$$R = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{\mathrm{n}(n^2-1)} \quad (1)$$

where $d_i = x_i - y_i$ for $i = 1,2, \ldots, n$ (Markechová et al. 2011). The Spearman rank correlation coefficient R takes values from the interval {-1,1}.

Another statistical method that we used is the analysis of time series. The issue of time series analysis is diverse. The use of time series sometimes allows the problem to be described by a mathematical function, other times the degree of irregularity and deviations in development is so high that the problem cannot be described mathematically and therefore the indicator cannot be predicted. One of the most important components of time series development is trend. Balancing time series using trend functions is one of the most commonly used methods in forecasting. Using trend functions, it is possible to capture the tendency of the investigated phenomenon. The development of the trend component can be described by various mathematical functions. The disadvantage is that we have to determine the type of trend function in advance on the basis of external assumptions and information, often subjective. A tool for determining the mathematical function describing the trend of the time series is also its graphical representation, which allows revealing in outline the basic trends in the development of the analyzed indicator. However, the risk of choice based on visual selection lies in its subjectivity. One of the most used methods for estimating unknown parameters of the trend function is the least squares method, while the suitability of the selected regression model can be measured by the coefficient of determination , which is given by Equation 2 (Ramík 2007):

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y}_i)^2} \quad (2)$$

Where $y_i (i = 1, \ldots n)$ are observed and $\hat{y}_i$ are the expected time series values i, $\bar{y}$ is the arithmetic mean. The coefficient of determination takes values from the interval {-0,1} and explains what part of the total variability is determined by the selected regression model. It is most often given as a percentage and expresses how many percent of the total variability is explained by the chosen regression model.

The choice of a suitable trend function can also be verified by hypothesis tests. One such test is the F-test, which is used to decide whether it makes sense to prefer a more complex model (with more parameters) to a simpler model (with fewer parameters). We tested the null hypothesis that the chosen model is not statistically significant compared to the alternative hypothesis that the chosen model is statistically significant. The larger the explained variability (sum of squares of the model) compared to the unexplained variability (residual sum of squares), the better the estimated regression curve models the dependence of the variables. In other words, the model with a larger number of parameters brings a significant improvement over a simpler model.

The aim was to use a suitable mathematical function to describe the development trend of imports of gold and silver jewelry imported from abroad for trading in the country for the period from 2010 to 2022 and to try to estimate the future development trend of these imports.

3 Results

As already mentioned, the import of gold and silver jewelry (in kg), which were imported to Slovakia in the years 2010 to 2022, was analyzed. Out of all countries from which gold and silver jewelry was imported in this period, we selected only seven countries for the analysis with the largest amount (in kg) of imported jewelry to Slovakia. Imported quantities of gold jewelry (in kg) of the seven largest importers to Slovakia in the years 2010 to 2022 are shown in the Figure 2.

Since we were interested in whether there was a relation in the import of the amount of gold jewelry between countries, using the Spearman rank correlation coefficient in the STATISTICA program, we calculated the values of the correlation coefficients between the imported quantities of gold jewelry to Slovakia (Table 1). The results of the correlation coefficients (correlation matrix) between countries with regard to the amount of gold jewelry imported to Slovakia (in kg) in the years 2010–2022 are presented in Table 1.

Based on the calculated values of the Spearman rank correlation coefficient, we can say that there is a high degree of relationship between imports of an amount of gold jewelry from Italy and Austria (R=0.753), i.e. the increasing amount of imports of gold jewelery (in kg) from Italy also corresponds to the increasing amount of imports of jewelery from Austria and vice versa (the correlation coefficient is symmetric). In addition, if imports from the first state increase, they also increase from the second and vice versa. There is also a significant degree of relation between the amount of imported gold jewelry between Italy and Turkey (R=0.687), Italy and Germany (R=0.687), as well as between Turkey and Austria (R=0.621) and Germany and Austria (R=0.538). There is also a significant degree of relation between the Czechia and Germany in the import of a number of gold jewelery while the correlation coefficient has a negative value (R=-0.511). This means that if the import of gold jewelry from Slovakia to the Czechia increases, it decreases from Germany and vice versa (symmetry). In other cases, the calculated values of the correlation coefficients are not statistically significant.

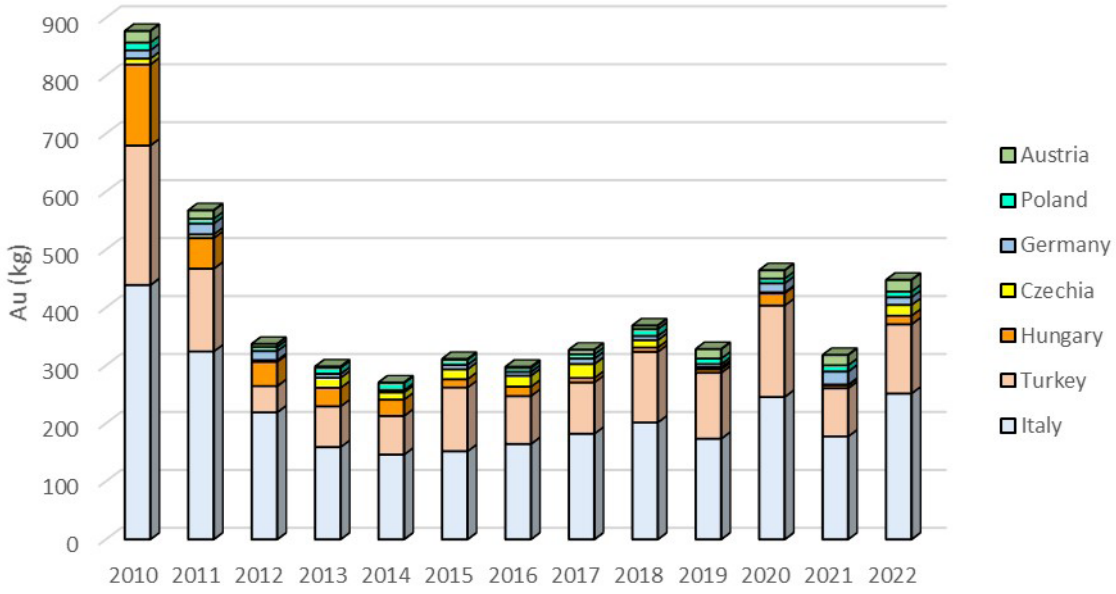

Figure 2 Countries of origin and weight of imported gold jewelery (in kg) submitted for hallmarking inspection at the Assay Office of the Slovak Republic in 2010–2022.

Table 1 Correlation matrix of imports of the amount of gold jewelry among countries to Slovakia (in kg) in 2010–2022.

Au	Italy	Turkey	Hungary	Czechia	Germany	Poland	Austria
Italy	1.000	0.687*	0.363	-0.258	0.687*	-0.016	0.753*
Turkey		1.000	0.060	-0.154	0.308	0.220	0.621*
Hungary			1.000	-0.038	0.181	-0.011	-0.104
Czechia				1.000	-0.511*	-0.148	-0.302
Germany					1.000	-0.148	0.538*
Poland						1.000	0.220
Austria							1.000

*statistically significant value

We proceeded analogously when calculating the correlation coefficient between the amount of imported silver jewelry to Slovakia (in kg) from individual countries (Figure 3).

As in the previous case, using the Spearman rank correlation coefficient, we calculated the values of the correlation coefficients between the imported quantities of silver jewelry (in kg) to Slovakia (Table 2).

Based on the calculated values of the Spearman rank correlation coefficient (Table 2), we can say that there is a very close relation between Italy and Germany in the import of amount of silver jewelry (in kg) (R=0.962), i.e. if the amount of imports of silver jewelery (in kg) from Italy increases, so does the quantity of imported silver jewelery from Germany and vice versa (symmetry). There is also a very close relation in the import of silver jewelry between Italy and Turkey (R=0.901). We speak of a high degree of relation in the amount of imported silver jewelry in kg based on the calculated value of the correlation coefficient between Hungary and Turkey (R=0.845), Turkey and Germany (R=0.890), Italy and Hungary (R=0.735) and Germany and Hungary (R=0.702). In the import of silver jewelry, there is a significant degree of relation between the states of Italy and Poland (R=0.571), Germany and Poland (R=0.577) and Turkey and Poland (R=0.543), i.e. we can say that if the import of silver jewelry from the first state increases, it also increases from the second state (also if the import in the first state decreases, it also decreases in the second state).

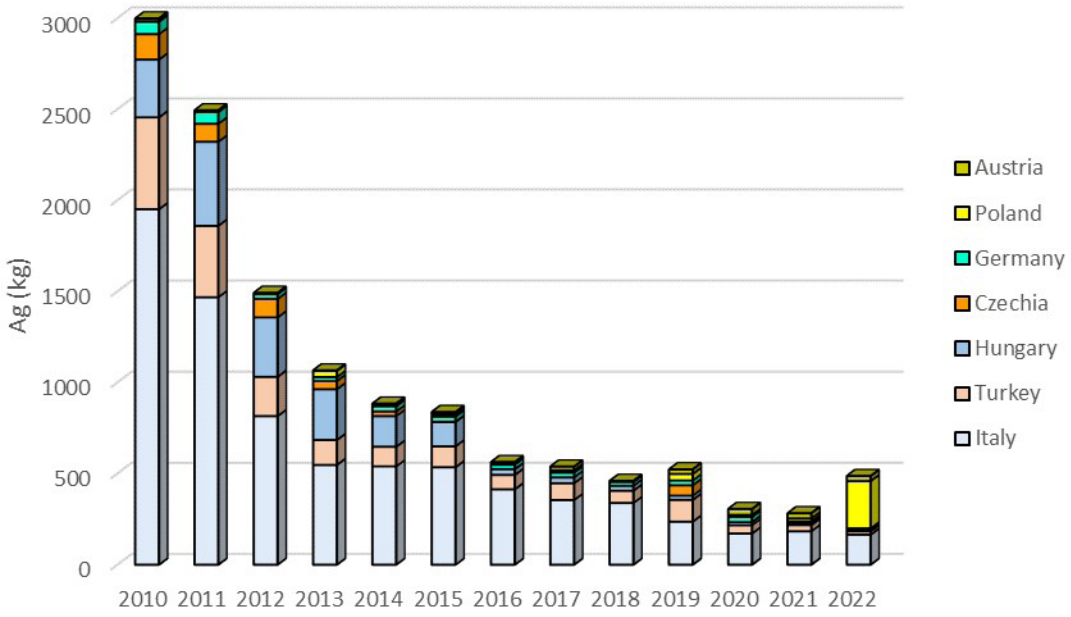

Figure 3 Countries of origin and weight of imported silver jewelery (in kg) submitted for hallmarking inspection at the Assay Office of the Slovak Republic in 2010–2022.

Table 2 Correlation matrix of imports of the amount of silver jewelry among countries to Slovakia (in kg) in 2010–2022.

Ag	Italy	Turkey	Germany	Hungary	Poland	Czechia	Austria
Italy	1.000	0.901*	0.962*	0.735*	0.571*	-0.626*	-0.560*
Turkey		1.000	0.890*	0.845*	0.643*	-0.484	-0.352
Germany			1.000	0.702*	0.577*	-0.626*	-0.560*
Hungary				1.000	0.453	-0.276	-0.193
Poland					1.000	-0.495	-0.016
Czechia						1.000	0.368
Austria							1.000

*statistically significant value

Furthermore, there is a significant degree of relation in the import of silver jewelery between the countries Czechia and Italy (R=-0.626), Czechia and Germany (R=-0.326), Austria and Italy (R=-0.560) and also between Austria and Germany (R=-0.560). The correlation coefficient is negative in all four cases. This means that if the import of gold jewelry from Slovakia to Czechia increases, it decreases from Italy and vice versa (symmetry). The interpretation is the same in the case of the correlation coefficient between Czechia and Germany, Austria and Italy and between Austria and Germany.

In other cases, the calculated values of the correlation coefficients were not statistically significant. This confirmed the validity of research hypothesis H1, i.e. there is a link between the selected countries due to the amount of gold and silver jewelry imported to Slovakia.

3.1 Time series analysis

Another method that we used in the analysis of imports of gold and silver jewelry to Slovakia was regression analysis and Holt-Winters method.

For our research, we formulated the following research hypothesis:

> **H2.** Based on the description of the development of the import of gold and silver jewelry from selected countries to Slovakia for the period 2010 – 2022, it is possible to estimate the future trend of the development of the import of the mentioned countries.

We will again verify the validity of the research hypothesis using statistical methods, namely regression analysis and the Holt-Winters method.

Given that, in order to verify the validity of the research hypotheses, we selected the countries of origin of gold and silver jewelry imported to Slovakia only from those countries that were the largest exporters of jewelry in terms of the amount of jewelry for the selected years 2010–2022. Moreover, when determining the trend of jewelry imports, it was necessary to approach each of the selected countries individually. The selected set included not only EU countries but also non-EU countries. For the stated reasons, we described the trend of jewelry imports to Slovakia for each country with a mathematical function that best described (captured) the trend of the time series for the period 2010–2022.

3.1.1. Import of gold jewelery

When choosing a mathematical function describing the trend of the relevant time series, we first proceeded from a graphical representation of the amount of imported gold jewelry to Slovakia (in kg), which are presented in Figures 4, 5 and 6.

Based on a graphical representation of the amount of gold jewelry imported to Slovakia for hallmarking in the years 2010–2022 (Figures 4, 5 and 6), we can see that in finding a suitable mathematical function that would describe the development trend of imports of gold jewelry from abroad, it will be necessary for each of countries to choose another appropriate trend function.

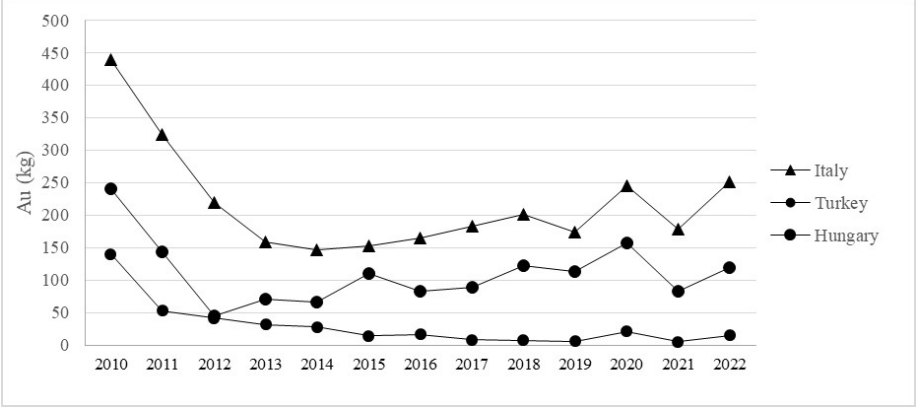

Figure 4 Imports of gold jewelry to Slovakia (in kg) in 2010–2022 from Italy, Turkey and Hungary.

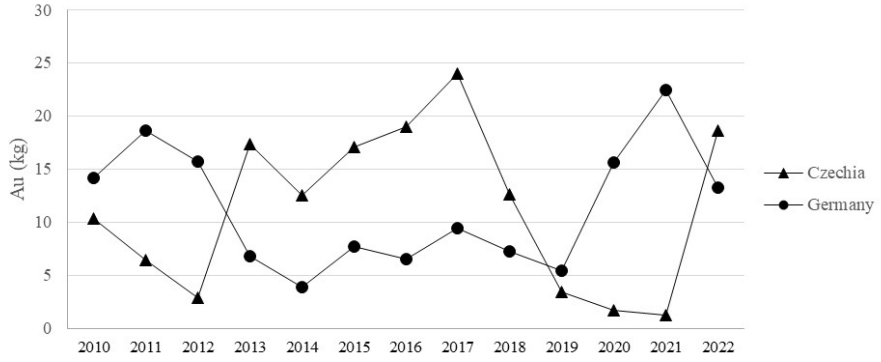

Figure 5 Imports of gold jewelry to Slovakia (in kg) in 2010–2022 from Czechia and Germany.

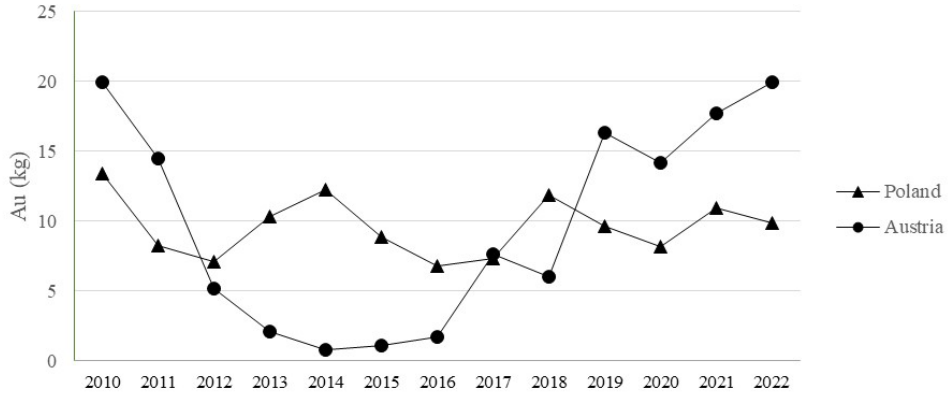

Figure 6 Imports of gold jewelry to Slovakia (in kg) in 2010–2022 from Poland and Austria.

As we have already stated, the goal of time series analysis is usually the construction of a suitable model, and another goal is to determine the trend of the time series development.

In addition to the classic analytical procedures for the analysis of trend development, based mainly on regression, there are also more computationally demanding analyzes such as the Box-Jenkins methodology and so on. Due to the fact that the length of the time series is also important when analyzing the time series, it is sometimes not possible to use more computationally demanding methods for balancing the time series. For example, to use the Box-Jenkinson method, it is recommended that the time series have at least 50 values.

To describe the development trend of imports of gold jewelry, the polynomial function was chosen as a mathematical function. We estimated the parameters of the relevant polynomial function based on the time series values using the least squares method. To model the trend component of the time series of jewelry imports, we used the mathematical function of parabola, i.e. the 2nd degree polynomial based on Equation 3:

$$\hat{y}_t = b_0 + b_1 t_1 + b_2 t^2 \qquad (3)$$

Where b_0, b_1 and b_2 are the parameters of the polynomial function, t is the time variable $\hat{y}_t$ and is the estimate of the value of the variable y at time t, i.e. an estimate of the amount of gold jewelry imported in kg the following year.

To illustrate, we present an estimate and prediction of the development trend of imports of the amount of gold jewelry imported from some countries. As a first example, we present an estimate of the development trend of imports of gold jewelry imported from Hungary for domestic trade for the period 2010 to 2022. Table 3 presents the results of regression analysis for the import of gold jewelry from Hungary.

Based on the obtained results, we can state that the chosen mathematical function (parabola) very well describes the development trend of imports of gold jewelry from Hungary. This is also proved by the result of the *F*-test, which we evaluated using the calculated value of probability $p = 0.007$. The *p*-value is the probability of error we make when we reject the tested null hypothesis in favor of the alternative hypothesis. If this probability is less than 0.05 or 0.01, we reject the tested null hypothesis at the level of significance α=0.05 or α=0.01. Otherwise, we will not reject the tested hypothesis.

Since the *p*-value in our case is less than 0.01, we reject the tested null hypothesis that the chosen model is not statistically significant at the level of significance and accept the alternative hypothesis that the chosen model is statistically significant. Based on the calculated value of the coefficient of determination (Multiple *R* is 0.81), we see that the chosen parabola mathematical function explains up to 81% of the variability of time series values.

The parabola equation for estimating the development trend of imports of the amount of gold jewelry (in kg) from Hungary in the years 2010–2022 has the following form Equation 4:

$$\hat{y}_t = 130.1 - 28.28t + 1.55t^2 \qquad (4)$$

Where t=1 in the year 2010.

An estimate of the development trend of imports of gold jewelery from Hungary is shown in Figure 7.

Table 3 Results of regression analysis for the import of gold jewelry from Hungary.

Regression Statistics						
Multiple R	0.90					
R Square	0.81					
Adjusted R Square	0.46					
Standard Error	26.62					
Observations	13					
ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*	
Regression	1	7868.16	7868.16	11.10	0.007	
Residual	11	7797.11	708.83			*Upper 95%*
Total	12	15665.27				110.31
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	-2.23
Intercept	75.83	15.66	4.84	0.00	41.36	*Upper 95%*

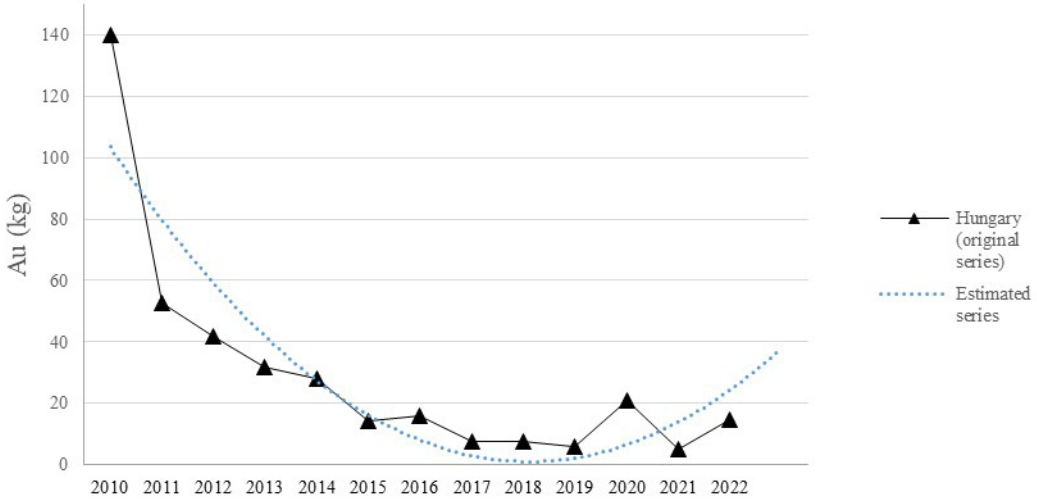

Figure 7 Estimation of the development trend of imports of gold jewelry from Hungary to Slovakia in 2010–2022.

Another example is an estimate of the development trend of imports of gold jewelry imported from Austria. Also in this case, we used a polynomial of the 2nd degree (parabola), which has the following form Equation 5:

$$\hat{y}_t = 22.48 - 6.18t + 0.49t^2 \quad (5)$$

where in the year 2010. This model explains 80% of the variability of time series values (Multiple *R* is 0.80). An estimate of the import trend of gold jewelery from Austria is shown in Figure 8.

3.1.2. Import of silver jewelery

We proceeded analogously in the search for suitable models of development trend of imports of silver jewelry regarding other studied countries. Even in this case, when choosing a mathematical function describing the trend of the relevant time series, we first used a graphical representation of the amount of imported silver jewelry to Slovakia (Figures 9, 10 and 11).

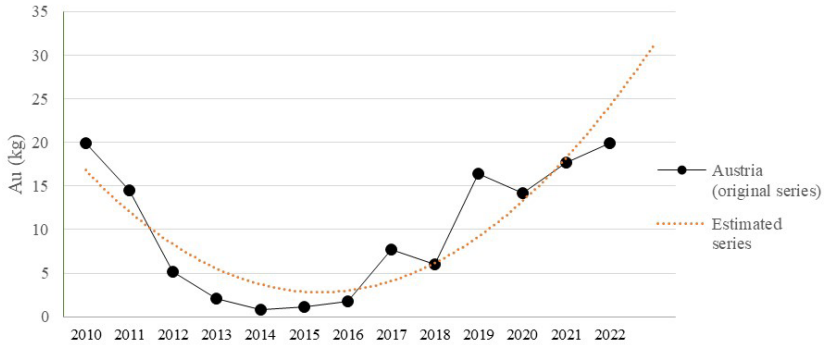

Figure 8 Estimation of the development trend of imports of gold jewelry from Austria to Slovakia in 2010–2022.

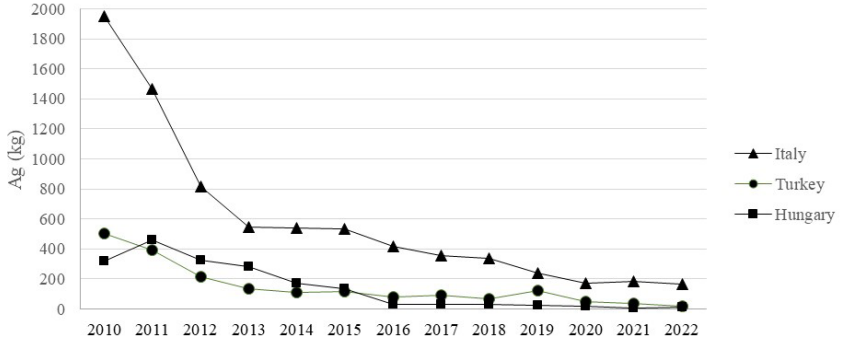

Figure 9 Imports of silver jewelry to Slovakia (in kg) in 2010–2022 from Italy, Turkey and Hungary.

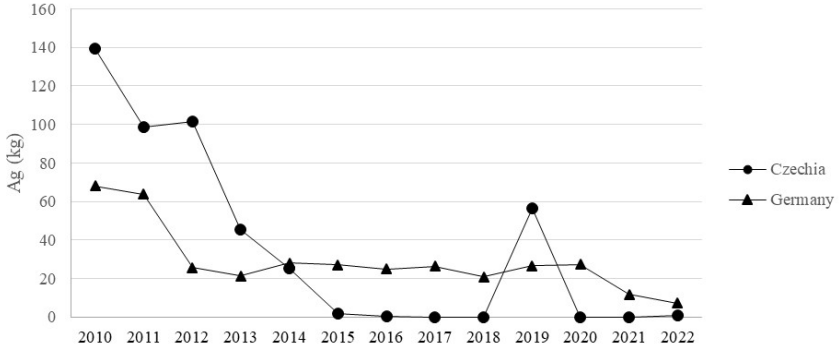

Figure 10 Imports of silver jewelry to Slovakia (in kg) in 2010–2022 from Czechia and Germany.

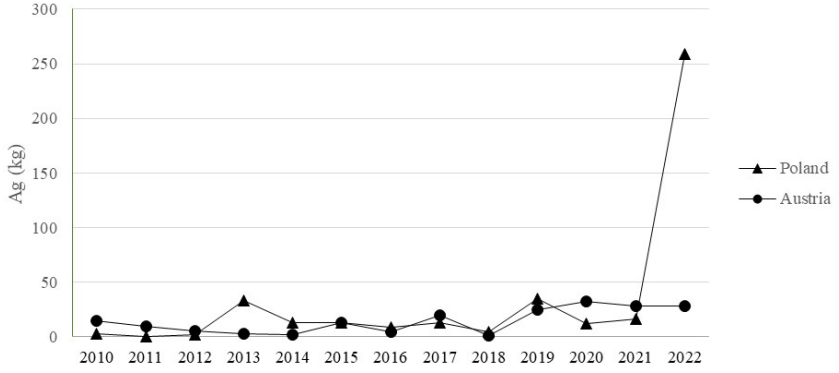

Figure 11 Imports of silver jewelry to Slovakia (in kg) in 2010–2022 from Poland and Austria.

Similarly as for modeling the trend component of the time series of imports of the amount of gold jewelry in some countries, we also used suitable mathematical functions to estimate the development trend of imports of silver jewelry. For the trend component of the time series of silver jewelry imports from some countries, it has proved more appropriate to use an exponential.

The exponential smoothing method was constructed by Holt, generalized by Winters (A), and the model is known as the Holt-Winters method (B).

The exponential smoothing procedure begins by setting the first smoothed value of the time series $\hat{y}_t$ (at time $t = 1$) equal to the observed value y_1, that is:

$$\hat{y}_t = y_1$$

We define other equalized values by a recurrence relation as seen in Equation 6:

$$\hat{y}_t = \alpha.y_t + \alpha.(1-\alpha).y_{t-1} + \alpha.(1-\alpha)^2.y_{t-2} + \cdots + \alpha.(1-\alpha)^{t-2}.y_2 + (1-\alpha)^{t-1}.y_1 \quad (6)$$

where:

$\hat{y}_t$ is the new balanced value, which is the forecast for the next period,

α is a balancing constant (weight) for which 0<α< 1 holds,

y_t is the observed value at time t,

$\hat{y}_{t-1}$ is the new balanced value at time t–1.

It can be seen from Equation 6 that the balanced value of the time series at time t is the weighted sum of the values of the series up to time t with exponentially decreasing weights

$$\alpha_{t-i} = \alpha(1-\alpha)^i$$

Where $i = 0,1,\ldots.t-2$

By modifying Equation 6, we get the following recurrence relation for simple exponential smoothing

$$\hat{y}_t = \alpha \cdot y_t + (1-\alpha) \cdot \hat{y}_{t-1},\ t = 1,2,3,\ldots,n,$$

Since it is clear that 0< α < 1 the value α_{t-1} decreases exponentially with the growth of the value of i, i.e. with the "aging" of the time series values.

To illustrate, we present the results in predicting the import of silver jewelry from Italy. The calculation was done in STATISTICA program. The equation of a mathematical function, which describes the development of the trend of imports of the amount of silver jewelry (in kg) from Italy in the years 2010 – 2022, is the exponential function that has this form Equation 7:

$$\hat{y}_t = 1709.e^{-0.194} \quad (7)$$

where t=1 in the year 2010. The model explains up to 95% of the variability of time series values (Multiple R is 0.949). An estimate of the import trend of the volume of imports of silver jewelery from Italy is shown in Figure 12.

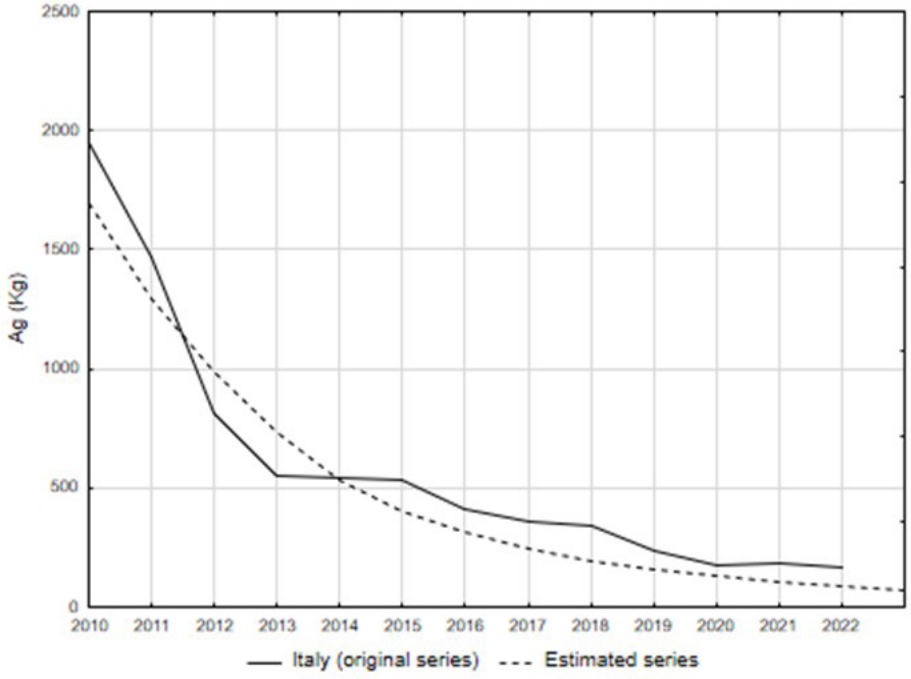

Figure 12 Estimation of the development trend of imports of silver jewelry from Italy to Slovakia in 2010 – 2022.

In the STATISTICA program, we also received a table with the original and estimated values of the amount of imported silver jewelry from Italy to the territory of Slovakia in the years 2010–2022 (Table 4).

From Table 4, we can see that the predicted amount of silver jewelry from Italy to the territory of Slovakia in 2023 is approximately 74 kg.

Another example is an estimate of the development trend of imports silver jewelry from Hungary. In this case, we used an exponential function to model the trend component of the time series of silver jewelry imports from Hungary, which has the following form Equation 8:

$$\hat{y}_t = 799.4.\, e^{-0.364} \quad (8)$$

Where $t = 1$ in the year 2010. The model explains up to 94% of the variability of time series values (Multiple R is 0.9428). An estimate of the import trend of silver jewelery from Hungary is shown in Figure 13.

Table 4 Original and estimated values of the amount of silver jewelry imported from Italy to the territory of Slovakia in the years 2010 – 2022.

Year	Exp. smoothing: S0=2250, T0=.7524 Expon. trend, no season; Alpha=.100 Gamma=.100		
	Ag (kg)	Smoothed Series	Resids
2010	1951.271	1692.532	258.739
2011	1468.102	1294.875	173.227
2012	815.536	990.106	-174.570
2013	547.683	732.610	-184.927
2014	539.884	536.522	3.362
2015	535.044	403.372	131.672
2016	413.844	313.991	99.853
2017	354.980	244.993	109.987
2018	338.862	194.451	144.411
2019	236.197	159.853	76.344
2020	170.880	128.781	42.099
2021	183.346	102.590	80.756
2022	164.877	86.041	78.836
2023		73.694	

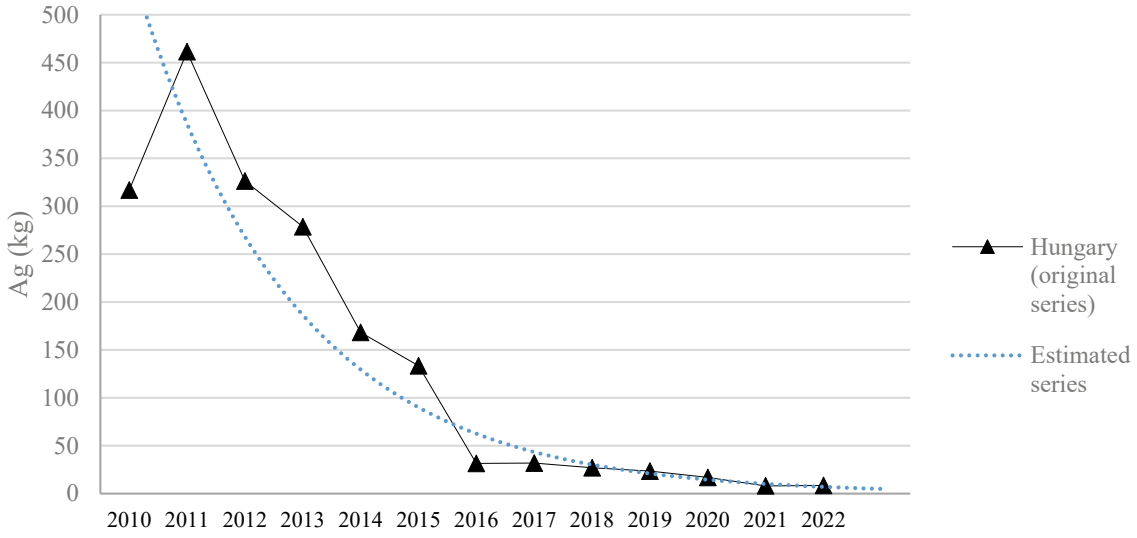

Figure 13 Estimation of the development trend of import amounts of silver jewelry from Hungary to Slovakia in 2010 – 2022.

This confirmed the validity of research hypothesis H2, i.e. j. based on the description of the development of the import of a number of gold and silver jewelry from selected countries to Slovakia for the period 2010 – 2022, it is possible to estimate the future trend of the development of imports of the mentioned countries using appropriate mathematical functions.

4 Discussion

The driving force behind gold imports is the country's demand. When it comes to the demand for gold, four areas are distinguished: investment, jewelry, industry and central banks. Gold trading is also seen as demand in a broader sense. Demand from end customers, as well as gold trading, can vary widely from country to country. There are countries where demand from the jewelry industry is particularly strong. These include India, Turkey or, in general, many states from the Asian and Arab regions. In other countries, on the contrary, investments in gold play a bigger role. This means coins or bricks. This is the case in Germany, for example. An important factor is also the central bank's demand for gold, such as in China, Turkey and Russia. In some countries, on the other hand, demand in the narrower sense is less decisive than gold trading. This explains why such a small country as Switzerland regularly occupies the leading positions when comparing absolute data on gold imports. Gold production also plays an indirect role, i.e. j. to what extent the country has its own gold mines. Not necessarily, because even countries without their own gold production can be very significant exporters of gold, as the examples of Switzerland and the United Kingdom show. The gold they export had to arrive in the country in advance (gold.de).

Since precious metals and jewelry are considered luxury goods rather than necessities of life, there is a trend for consumers to hold back on purchases during economic downturns to reduce household spending. According to the Guidebook for Export to Japan (JETRO 2011), demand fell further in 2008 due to the global financial crisis, remained at its lowest level in 2009, and showed a slight recovery in 2010. The import of precious metals and jewelry is in line with domestic demand. According to the World Gold Council (WGC), the demand for gold is significant, although its mining has stagnated, its supply has increased in recent years due to increasing recycling and hedging. After 2020, the intensification of market and geopolitical risks, negative real interest rates and the expected slowdown in global economic growth will have the greatest impact on its price.

The task of regression analysis was to find a suitable mathematical function that will determine as accurately as possible the trend of gold or silver jewelry imports from the analyzed countries to Slovakia. The most accurately estimated mathematical function then allows predicting the imports from the country to Slovakia in the future.

Based on the obtained results, we can state that the amount of imported gold jewelry from Hungary will continue to grow for the next years. For example, in 2023 we predicted the import of gold jewelry from Hungary to be about 38 kg, which is almost double the import in 2022.

According to the estimated development trend of gold jewelery imports from Austria for pruning, we assume that the amount of gold jewelery from Austria will continue to grow. For example, in 2023 we predicted the import of gold jewelry from Austria to be about 31 kg, which is 55% more than in 2022.

Regarding, the estimation of the development trend of gold jewelry imports for other countries, we assume the increase in gold jewelry imports from Turkey, Germany, Poland and the Czech Republic. We recorded an increase in imports of gold jewelry in 2022 from all selected countries. As we can see, in 2021, due to the Covid-19 pandemic, there was an overall decrease in imports, but in 2021 there was another increase in imports of gold jewelry to Slovakia. As a result of pandemic market uncertainty, gold has become a sought-after investment, with global demand for gold and its price rising. Precious metal prices rose by almost 12% after growing uncertainty. Hošoff et al. (2020) states that the value of Russian gold exports have risen and, as a result, exports of other "non-oil" commodities have not shown such a large year-on-year decline. The COVID-19 period also caused gold and silver prices to fall, but silver prices quickly bounced back. The prices of these two commodities show according to Yaya et al. (2021) to some extent likely co-movements, gold and silver stock indices fell sharply during the COVID-19 pandemic period from March to April 2020 and stock markets recorded higher performance.

On the contrary, exports of other key export items suffered at the beginning of 2020, both the amount and value of exported coal, ferrous metals and aluminum, wood, wheat and fertilizers decreased (CBR 2020). Jain (2021) also states that the COVID-19 pandemic also affected the decline in gold and silver mining and other ore resources in India.

The strength of demand for silver jewelry differs between countries. This is mainly due to cultural attitudes, consumers consider silver to be a more fashionable piece of jewelry than gold (Newman 2020). From 2014 to the present, Italy supplied 23% more silver jewelry to the rest of Europe. This significant demand was based on the fact that the price of silver fell by 20% compared to gold. According to Yaya et al. (2021), however, the drop in silver prices did

not last long, the revival of the American economy caused an increase in these prices by 10%. When we look at the estimate of the import trend of silver jewelry from Italy, for example, in 2023 it is estimated to import about 8.5% more kg than in 2022, which is a very slight increase. On the contrary, based on the estimated trend for imports of silver jewelery from Hungary, it is estimated that up to 75% less silver jewelery will be imported than in 2022, while in 2021 51% less silver was imported than in 2020, i.e. in in this case, it is a significantly declining trend.

Based on the results obtained by estimating the development trend of silver jewelry imports for other countries, we assume that the increase in silver jewelry imports to Slovakia in 2023 could be from Italy, Czechia and Austria, and vice versa that imports of silver jewelry from Turkey, Hungary, Germany and Poland should decrease compared to imports in 2022. Turkish jewelery production continues to grow, although silver still makes up a relatively small part of domestic consumption, but it managed to gain ground against gold after its value expressed in Turkish lira rose by 3.5%. The government's tightening of credit card payments when purchasing jewelry also had an impact on the domestic consumption of jewelry. It benefited silver, which fell in value after buyers lost interest in more expensive items. After the silver price fell by 7.4% in Turkish lira terms, Turkish producers were so competitive that they were able to appreciate their exports by about 8%.

As for the import of silver, we can see that the COVID-19 pandemic did not have a significant impact on the purchase of silver jewelry, however, the demand for this product decreased.

According to Baláž and Hanas (2006), the position of gold and silver in the markets is strong and it has the potential to maintain and also strengthen this position according to the analysts. Rising inflation strengthens this position and pushes the price of gold and silver up. If interest in these metals persists, intensification of its mining and the opening of new deposits can be expected. Demand for gold grew most markedly in investment, which is likely to continue, and demand growth in the jewelery sector is expected to grow in the long run.

The World Gold Council (WGC) has identified six major global economic trends that could support gold demand and affect the price of the yellow precious metal: increased political and geopolitical risks, currency devaluation, rising inflation expectations, overpriced stock markets, developments in long-term Asian economic growth, and opening new markets.

Higher production of these precious metals is made possible by new economic conditions, i.e. the profitability of mining and production as well as technological improvements affecting both exploitation and processing. At the same time, the current expansion of mining is forcing miners and entire countries to intensify mining and further exploration of exploited gold deposits, as well as to look for new indications and deposit structures. On the other hand, gold sales are stagnating to some extent due to its relatively high price, which indirectly reflects the global crisis caused by the terrorist attack on the United States on 11 September 2001, the war in Iraq, as well as other conflicts and natural disasters. The situation is complicated mainly by energy raw materials, i.e. oil and natural gas, the price of which has risen sharply, which has a significant positive and negative effect on the economies of individual countries of the world, but also indirectly on the world price of gold. Although 3rd millennium gold also has a higher utility, especially in electrical engineering (Bakos & Chovan 2004), it continues to play a key role in banking and jewelery, where it is still a symbol of stability, wealth and beauty (Ďurove et al. 2006).

The European Union is also dependent on the removal of ores and metal concentrates, and many European deposits can be expected to be further re-evaluated. Each, but especially the precious metal, bearing is unique in its own way. Due to the non-renewable resources as the demand for such a valuable raw material as precious metals grows, poor deposits will soon be exploited. Due to the very low content of the components to be obtained, the technology is demanding and it is also associated with environmental risks (Jeleň et al. 2007; Hronček 2008; Hronček et al. 2018; Reiffers et al. 2018; Torma et al. 2019).

Slovakia has also a sufficient amount of ore raw materials, including precious metals such as gold and silver. For example, Blišťan et al. (2009) state that mining has not started here again, due to the economic complexity of mining, mining technology and processing, but also due to various campaigns against the resumption of mining activities, it confirms the growing aversion of part of the Slovak society against mining.

5 Conclusion

The outbreak of the crisis, which began essentially at the end of 2019, gradually took on a pandemic dimension. It is true that the virus has gradually spread from China to Europe, the United States and other countries, and in 2022 the virus curve spreads across the planet from Africa to Australia. This key issue has shown that resolving the crisis in 2008, despite issuing a huge amount of financial resources, did not address the real causes that arose then and are recurring in a new form. At the same time, there has been a degree of vulnerability in today's society based

on the role of the financial sector in the corporate sector, employment, but especially on the constant growth of global consumption (Hošoff et al. 2020).

In financial, political and other crises, where there is financial and political uncertainty, gold is becoming more and more attractive to funds, central banks and small investors. The fact that the price of gold is closely linked to the global economic situation proves that private investors bought large quantities in 2008. That year, the crisis in the financial markets culminated. At the time, according to CPM Group, they bought 41.7 million ounces, in 2009 it was 37 million ounces. Central banks also bought more gold in 2009 than they sold. At the same time, the last few decades since the so-called gold standard (covering currencies with gold) stopped to be valid, they sold their gold massively. Banks consider gold to be a good security in times of and immediately after a crisis. In 1979 and 2008, the uncertainty caused by the global crises caused investment madness and the price of gold soared. The sharp rise in the price of gold then also occurred during the COVID-19 pandemic, which engulfed the world at the beginning of 2020. Demand for gold in this case far exceeded supply, and many distributors reported a sell-off. It is true that people turn to gold with confidence, especially in times when they fear the devaluation of their money.

Using statistical methods, we described the trend of imports from selected seven countries with the largest amount of gold and silver jewelry, i.e. the largest importers of gold and silver jewelry in Slovakia in the years 2010 – 2022, which were sealed by the Assay Office of the Slovak Republic. Subsequently, we used appropriate mathematical functions to estimate the future trend of these imports of gold and silver jewelry imported from abroad for trading in the country for the period 2010 to 2022 and we tried to estimate the future development trend of these imports. We found out that the import of silver jewelry to Slovakia has a mostly declining trend and, conversely, the import of gold jewelry has an upward trend.

The analysis of the development of the world price of gold, but also the trend of its world production, shows that it is a mirror image of the overall world economic policy situation. The turn of the millennium meant great changes as a result of the increasing globalization of the world, which on the one hand brings the spread of democracy, but on the other also war conflicts and a new threat to humanity, in the form of terrorism. In addition, these phenomena are accompanied by natural disasters, which puts humanity in a very difficult situation. The economies of developed countries are not advancing at the pace at which their populations are accustomed, and developing countries are not progressing in such a way that they can satisfy at least the basic living requirements of their populations. This raised concerns about energy resources at the beginning of the third millennium, thus oil and, with some delay, natural gas became more expensive, which was reflected in the prices of other minerals. This was particularly pronounced in the case of gold, the price of which has been rising since March 2002 (Ďurove et al. 2006).

Trade relations continue to be marked by rivalry between the United States and China, as well as by the world trade situation. Both aspects are strongly accompanied by a coronavirus pandemic. The United States is characterized by efforts to limit China's influence on its domestic economy, as well as to limit China's strengthening position in the world. US measures are limited by China's position in the mining, processing and supply of precious metal minerals, which are indispensable in the electrical and military industries. China's importance is that it controls the production of precious metals at home and abroad. The problem in recovering precious metals from the extracted raw material is the high environmental load during its processing (Hošoff et al. 2020).

Conditions for mining and exploration of gold deposits have improved, but its high price complicates sales, as conditions for customers have deteriorated considerably. With the beginning of the gold ore mining boom, its stability may also be disturbed by the gold reserve in central banks, which represents about fifteen years of world mining. This gold still serves as a monetary metal and a monetary fund, but it does not cover the currencies of individual countries as much as in the past, and therefore the sale of more gold from these institutions could lead to a certain decline in its world price. However, the biggest risk to the stability of the world price of gold is the current global economic and political developments, especially those affecting the price relations of the most important energy raw materials, i.e. oil and natural gas, but also the current situation associated with the COVID-19 pandemic.

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Anna Tirpáková: conceptualization; methodology; software; formal analysis; writing – original draft. **Jana Vojteková:** conceptualization; methodology; software; formal analysis; writing – original draft. **Iveta Opálená:** resources; data curation; writing – original draft. **František Petrovič:** resources; formal analysis; writing – review and editing. **Gabriela Repaská:** resources; formal analysis; writing – original draft. **Matej Vojtek:** software; formal analysis; writing – original draft, writing – review and editing.

Conflict of interest

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