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GERGANA TANEVA-ANGELOVA

Department of Finance and Accounting, University of Plovdiv Paisii Hilendarski, Bulgaria

STEFAN RAYCHEV

Department of Economic Science, University of Plovdiv Paisii Hilendarski, Bulgaria

EXAMINING THE CORRELATION BETWEEN GOLD PRICE FLUCTUATIONS AND UNEMPLOYMENT LEVELS IN THE CONTEXT OF GREEN TRANSITION: INSIGHTS FROM TIME SERIES ANALYSIS AND GRANGER CAUSALITY

Abstract:

This article tackles the complex task of establishing a correlation between the volatility in gold prices and levels of unemployment, while considering the emerging influences of green economics and the green transition. We employ regression analysis, cluster analysis, time series, and Granger causality to investigate the relationship between gold prices—a traditional safe-haven asset and alternative income source—and unemployment rates, particularly during periods of economic uncertainty. As economies shift toward sustainable development, green investments are altering traditional economic dynamics, potentially affecting the role of gold as a security asset.

This empirical study tracks these interactions from 2019 to 2024, using data from the EU27. This period encompasses significant economic and geopolitical challenges—including the COVID-19 crisis, military actions in Ukraine, and inflationary pressures—as well as a stronger emphasis on green transition policies. Central banks have responded by increasing interest rates, enhancing the appeal of investment assets such as bonds and gold. Meanwhile, labor markets have experienced disruptions, with evolving employment patterns due to the green transition and heightened unemployment across European countries.

Keywords:

Green economics, Green transition, Sustainability, Gold price volatility, Unemployment levels, Labor market dynamics, Economic indicators, Time series analysis, Granger causality

JEL Classification: E44, C32, Q01

1 Introduction

The present study examines the relationship between gold as an investment asset and unemployment rates in the EU27 during the period from 2019 to 2024. This period is highly dynamic, characterized by multiple factors influencing investment decisions. The COVID-19 pandemic, military actions in Ukraine, inflationary pressures, and the EU's ambitious green transition have all contributed to the complexity of the market environment, affecting both traditional and emerging investment assets. Given these influences, an in-depth analysis is needed to determine the potential correlation between the upward trend in gold—reaching \$2400 per troy ounce in July 2024—and the fluctuating unemployment rates in the EU27 from 2019 to 2024.

The analysis recognizes that this period marks a pivotal point in Europe's economy, not only for traditional assets but also for the evolving landscape shaped by green economics. As the EU has committed to significant environmental targets, the green transition has prompted shifts toward sustainable, low-carbon investments, influencing how both investors and policymakers approach economic growth and labor market stability. The demand for sustainable assets has grown alongside investments in green infrastructure, renewable energy, and job creation in sectors aligned with environmental goals. This shift challenges the stability and demand for traditional safe-haven assets like gold, as green investments provide alternatives that align with the EU's sustainability objectives.

The value of gold has increased by over 70% since 2019, coinciding with a rise in unemployment in the EU27 at the onset of the studied period due to government restrictions during the COVID-19 pandemic. This led to a reduction in aggregate demand and economic activity. As a result, consumers and investors faced difficulties due to decreased disposable income, lower purchasing power, and challenges in making investment decisions. At first glance, it appears that there is an inverse relationship between the price of gold and the level of unemployment, as reduced economic activity typically leads to fewer investment opportunities and decreased demand for gold, which would presumably result in a decline in its value.

However, after 2021, rising inflation rates, increasing commodity prices, and currency depreciation drove investors towards safe-haven assets that could preserve the value of their investment portfolios. During this period, gold not only increased in value due to heightened demand from professional and individual investors, as well as institutions, but also demonstrated its role as a hedge against inflation and market instability, particularly during times of military conflict. It serves specifically as an asset that can protect investment portfolios and generate additional income.

In parallel, the EU's green transition has begun to impact investor behavior and capital allocation patterns. With increasing interest in sustainable investments, investors are gradually diversifying their portfolios to include green bonds and renewable energy funds, which provide environmentally aligned alternatives to gold. This shift is significant, as it suggests that the demand for traditional assets like gold could be affected as green investments become more prominent in institutional and individual portfolios. Additionally, green job creation in sectors like renewable energy, energy

efficiency, and sustainable agriculture has introduced new employment opportunities, potentially counterbalancing unemployment rates affected by crises in traditional sectors.

Given the key role of gold during market crises, often associated with rising unemployment levels, our aim is to explore the relationship between gold prices and unemployment rates and to determine whether there exists an inverse or direct correlation between the asset and the macroeconomic variable in dynamic market conditions shaped by the green transition. The choice of topic is based on two key aspects. First, there is a lack of comprehensive research into the relationship between two crucial economic indicators: gold, a key safe-haven investment asset, and unemployment, a macroeconomic indicator reflecting labor market conditions and economic activity within a country. Second, the analysis would contribute to a deeper understanding of economic processes and provide valuable information for making economic, financial, and political decisions related to labor market dynamics and the influence of gold on investment decisions.

Although the relationship between the price of gold and unemployment is underexplored, such an analysis could facilitate investment processes, forecasts of economic trends, and research related to macroeconomic stability. Furthermore, as the EU continues its transition towards a sustainable economy, understanding how traditional assets and macroeconomic variables interact in this shifting landscape can offer valuable insights for both policymakers and investors navigating the complexities of a green economy.

In this context, the study further considers the impact of green transition policies on labor markets and investment decisions, examining whether the increasing prevalence of sustainable investments and green job creation alters traditional economic relationships. The results are expected to shed light on how environmental policies and economic shifts toward sustainability interact with traditional financial and macroeconomic indicators, contributing to a nuanced understanding of these interactions in a transitioning economy.

2 Literature review

During economic upheavals, the demand for gold tends to increase as a means of hedging investment portfolios. Historically, gold has proven to be a safe-haven asset favored by investors because it retains its value over the long term, especially during downturns in the business cycle (Michael Maloney, 2015). We consider gold a stable asset for two primary reasons: first, during economic downturns and rising unemployment, central banks often implement expansionary monetary policies, which typically involve lowering interest rates and reducing yields on certain financial instruments. This drives investors to seek gold as an alternative, potentially more profitable investment. The second reason relates to inflationary pressures, increased market uncertainty, and reduced purchasing power, all of which can lead to rising unemployment levels. In such conditions, central banks may adopt restrictive monetary policies, believing that high inflation can be controlled by increasing interest rates. These market conditions establish gold's role as a stable asset, a hedging instrument, and a means of diversifying investment portfolios.

The dynamics of gold's value from 2019 to 2024, influenced by various market phenomena such as COVID-19, the conflict between Russia and Ukraine (Morina et al., 2024; Shaik et al., 2023),

and inflationary processes in economies like the United States and European countries (Gold Demand Trends Q1 2024; Burdekin, Richard, and Tao, 2021; Izzeldin et al., 2023), have been well-researched in the academic community. The strong correlation between military conflicts, the pandemic, and inflation with the upward trend in gold prices (Morina et al., 2024) highlights the critical role of this asset in the investment decisions of economic agents. When forming long-term investment strategies, traders increasingly turn to gold, viewing it as a stable asset capable of preserving portfolio value. The low interest rates maintained by central banks as part of expansionary monetary policies at the beginning of the studied period played a significant role in the dynamics of gold prices, steering investors towards it as a better alternative for yield. The policy of lowering interest rates reduced yields on some financial instruments, making gold a favorable addition to diversified portfolios for investors seeking protection against economic turbulence (Zulaica, Omar, 2020).

The studied market conditions reveal a clear dependence between global economic growth and the dynamics of demand for investment gold (Gold and the International Monetary System, 2021), including its use in strengthening central bank reserves, especially in emerging markets (Arslanalp, Eichengreen, and Simpson-Bell, 2023). The military actions in Ukraine led to increased demand for gold from central banks, a trend observed in data from international financial institutions and academic analyses (Ito, Hiro, and McCauley, 2020; Arslanalp et al., 2022; IMF, Global Financial Stability Report, 2024). Russia, China, Turkey, and India have adopted strategies to diversify their reserves, increasingly acquiring investment gold (WGC, Gold Outlook, 2020; Gold Demand Trends, Q1 2024). This strategy aims to protect against currency risks, facilitate financial consolidation, and navigate political and economic disruptions. The geopolitical conflict has further complicated economic conditions by exacerbating inflationary pressures due to rising energy prices.

However, the green transition also plays an emerging role in shaping investment behaviors and affecting traditional asset classes like gold. As the EU and other regions increasingly prioritize green and sustainable investments, capital flows are gradually shifting from conventional safe-haven assets toward sustainable options like green bonds, renewable energy stocks, and climate-resilient infrastructure investments. This trend reflects a broader alignment with green economics, where economic policies and investments focus on sustainable development and long-term environmental goals. Consequently, as green investments become more attractive, the demand for gold may face fluctuations as investors seek assets aligned with sustainability objectives.

The devaluation of currencies resulting from increasing inflation, post-pandemic restrictions, and military complications forced central financial institutions to shift from expansionary to restrictive monetary policies. In an environment of rising interest rates, gold again gains significance as a proven reliable financial instrument for hedging risk and preserving the value of investment portfolios during inflation (Richard, Burdekin, and Tao, 2021). A series of academic and market studies examine gold's behavior in the context of crisis phenomena and analyze various interrelationships, including those between employment, economic growth, and gold price volatility (Kiohos and Sariannidis, 2010).

Research has repeatedly demonstrated gold as a safe-haven asset (Ciner, Gurdgiev, and Lucey, 2013; D.G. and Lucey, 2010; Beckmann, Berger, and Czudaj, 2015), an investment asset that

diversifies portfolios (Erb and Harvey, 2013), a hedging instrument against currency fluctuations (Capie, Mills, and Wood, 2005; Reboredo, 2013), and against inflationary processes. Studies have also explored the long-term relationship between gold and the Consumer Price Index (Ghosh et al., 2004; Aye et al., 2016; Jonathan et al., 2014; Baur et al., 2016). The results of these analyses indicate that changes in expected inflation undoubtedly influence gold prices, but unexpected changes in CPI levels do not have the same impact on the spot prices of the asset.

Macroeconomic indicators, including interest rates and unemployment, are influenced by information flows and affect the dynamics of gold (Qi Liang et al., 2021). Empirical studies on the impact of unemployment and inflation levels on gold demand and price volatility (Inflation: a rare SMSF consideration, 2023; WGC, Blose, 2010) further contribute to discussions about the role of gold. Numerous studies have confirmed the critical economic role of gold throughout various business cycles in historical perspective (Bernstein, 2000) and established its function as a safe-haven and long-term hedging instrument (Baur and Lucey, 2010). The studies show that gold prices can rise in tandem with inflation, providing an effective long-term hedge against inflation, but at the same time, the demonstrated model shows that short-term changes in interest rates and the US dollar exchange rate can disrupt this relationship, causing significant short-term volatility.

In this context, although gold can be an effective long-term safe-haven asset, its value is subject to significant short-term volatility due to various economic events. Such analyses are crucial for investors taking long positions in gold to hedge their portfolios but can also present significant challenges in the short term, potentially leading to losses in the real value of investments. The nonlinear dynamics between gold returns and the returns of the FTSE 100, S&P 500, and NIKKEI 225 indices during the global financial crisis in the UK have been documented, showing limited evidence of an inverse relationship before the crisis (Taufiq et al., 2015; Balcilar, Ozdemir, and Ozdemir, 2021). There are several studies examining macroeconomic factors such as GDP, interest rates, and the dollar index and their influence on changes in gold prices (Sun, 2018).

In present study, we focus on analyzing gold and its impact on unemployment under inflationary conditions, tracking the influence of exogenous factors such as pandemic conditions and the military actions in Ukraine. The goal is to build on the existing literature related to the influence of gold in a dynamic period when many investors turn to it. The study will provide clarity on the relationship between increased investments in gold and rising unemployment during a crisis and how these exogenous factors affect the interrelation of the two indicators. Our choice of methodology is based on numerous analyses proving the complex conditions associated with the hedging functions of gold, used by investors as a safe haven during inflation (Ghosh et al., 2004; Aye et al., 2016).

3. Methodology

The methodology in this article uses the tools and methods of economic statistics to test the correlation and dependence between the fluctuations in the price of gold and the levels of unemployment. Gold price and unemployment rate serve as pivotal indicators, reflecting the dynamics of the economic landscape from various angles. During times of economic turmoil, gold often emerges as a safe haven asset, leading to a surge in its price. Concurrently, economic downturns typically coincide with spikes in the unemployment rate due to the cyclical nature of

business activity. Consequently, in periods of economic crisis, both gold prices and unemployment rates are anticipated to rise, whereas during periods of economic expansion, a decline in both parameters is expected. This article undertakes an empirical examination of this relationship employing supervised and unsupervised learning techniques, alongside time series analysis tools such as Granger causality. The dataset comprises international gold prices and unemployment rates for the EU27 region, spanning monthly observations from 2019 to 2024. Additionally, regression and polynomial regression analyses, cluster analysis, as well as graphical, descriptive, and variance analyses, are employed to further explore and validate the identified correlations and dependencies within the dataset.

Gold, often perceived as a symbol of wealth and stability, holds a unique position in the global financial ecosystem. During times of economic uncertainty or geopolitical instability, investors tend to flock towards gold as a safe haven asset, driving up its price. The rationale behind this behaviour lies in gold's intrinsic value, scarcity, and historical track record as a store of value. Consequently, fluctuations in the price of gold can serve as a barometer of market sentiment and macroeconomic stability. In contrast, the unemployment rate is a key macroeconomic indicator reflecting the health of the labour market and overall economic performance. High unemployment rates are typically associated with economic downturns, signalling reduced consumer spending, declining business investment, and heightened financial stress.

The analytical framework adopted in this study encompasses both supervised and unsupervised learning methodologies to explore the complex relationship between gold prices and unemployment rates. Supervised learning techniques, such as regression analysis, enable the identification of linear and non-linear relationships between variables, facilitating predictive modelling and trend analysis. In contrast, unsupervised learning techniques, such as cluster analysis, allow for the identification of distinct patterns or clusters within the dataset, shedding light on underlying structures and correlations that may not be immediately apparent.

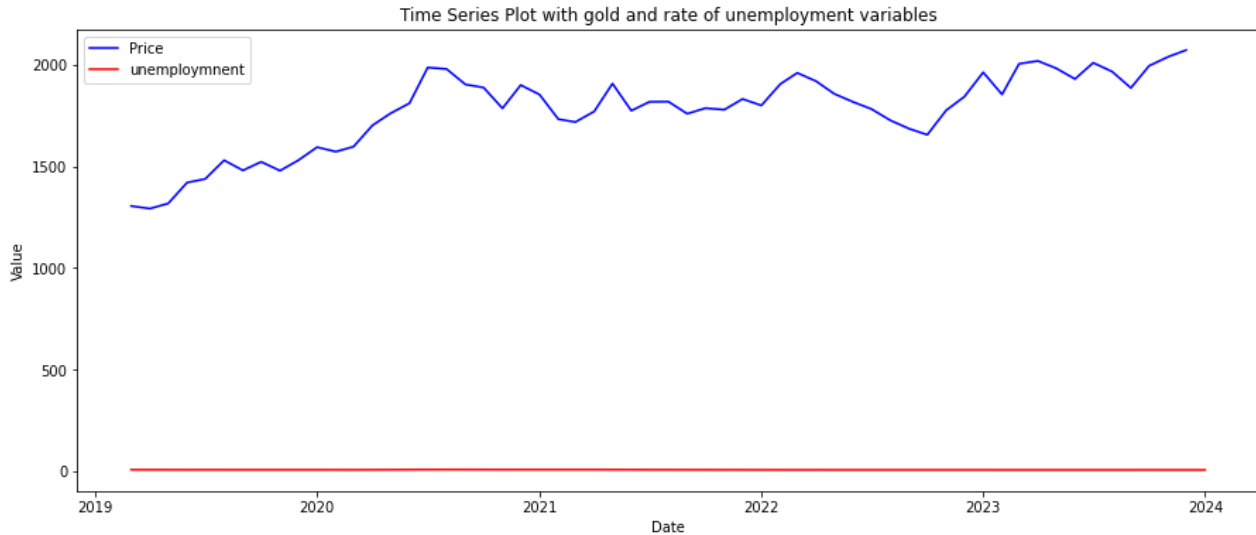
Time series analysis techniques, including Granger causality is used to assess the temporal dynamics and causal relationships between gold prices and unemployment rates. Granger causality analysis helps discern the directionality of causal relationships between variables. By analysing the lagged effects of changes in gold prices on subsequent changes in unemployment rates, and vice versa, the study seeks to uncover potential lead-lag relationships and feedback mechanisms between the two variables.

4. Conducting research and results

Using time series analysis, we are concerning the dynamics between the unemployment rate and the price of gold. We are confronted with a significant difference in the measurement scales of these two crucial economic indicators. On one hand, the price of gold is quantified in absolute dollar values, encapsulating its tangible monetary worth within the global market. On the other hand, the unemployment rate is calculated as a percentage ratio, based on the proportion of individuals unemployed relative to the total labour force, thereby offering insights into the prevailing employment landscape. This contrast in measurement units not only underscores the multifaceted nature of economic analysis but also underscores the complexities inherent in interpreting the

interplay between these two variables. The dynamics of price of gold and the unemployment rate is plot in Figure 1.

Figure 1 Time series analysis of gold price and rate of unemployment in EU 27 (monthly 2019-2024 year)

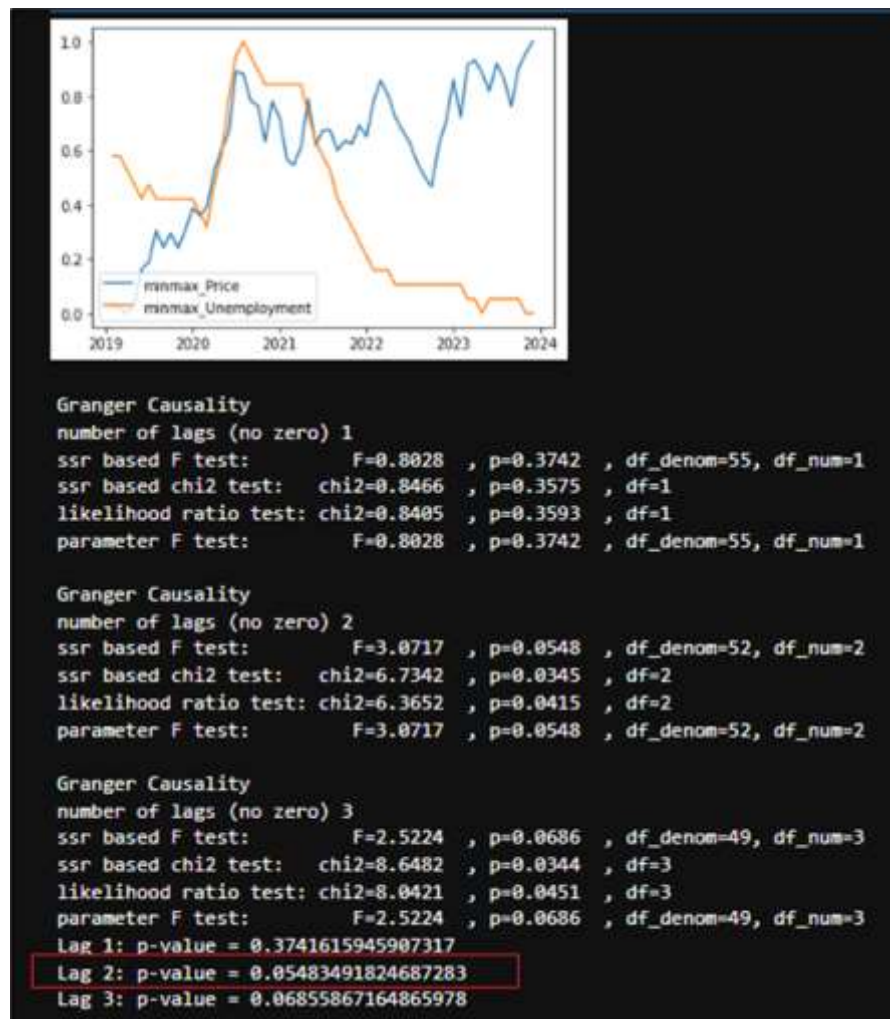


Source: European commission.

Figure 1 shows why we needed to change the data. The unemployment rate and gold prices are measured differently, so we used a method called min-max scaling to make them easier to compare. This method ensures both variables are adjusted to fit within the same range, making it easier to analyze them together.

After scaling the data, we used the Granger method to explore the relationship between unemployment rates and gold prices. This method helps us understand how one variable affects another over time by looking at past values. Figure 2 summarizes our findings from this analysis, highlighting the connection between unemployment rates and gold prices. Our goal is to provide useful insights for decision-makers by carefully analyzing economic trends and relationships.

Figure 2. The Granger Causality analysis for gold price and rate of unemployment in EU 27 (monthly 2019-2024 year)



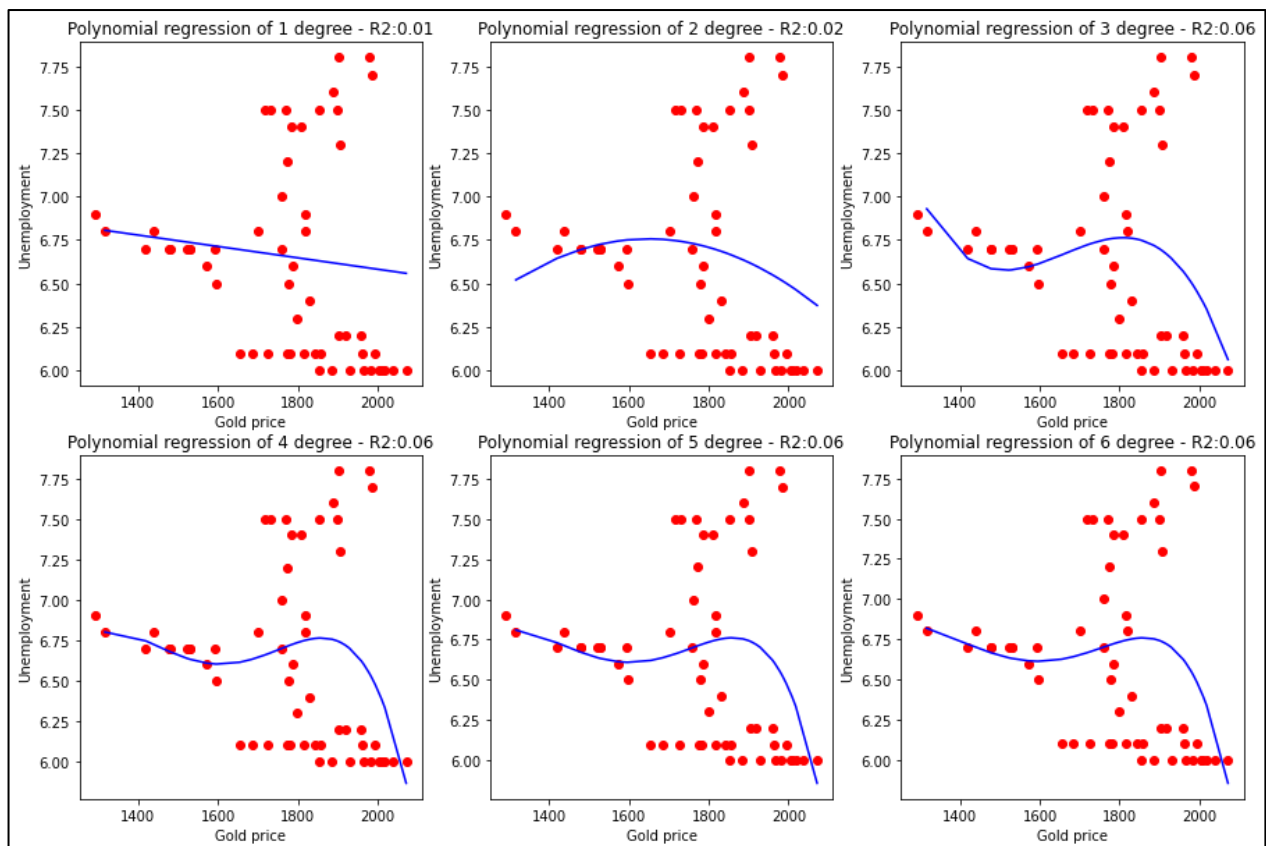
Source: Own calculations.

The results presented in Figure 2 show a series of Granger causality tests applied to normalized (minmax) gold price and unemployment rate data. Over the various lags tested, the p-values remain consistently above the 0.05 threshold, indicating no statistical evidence to support the hypothesis that past values of gold prices can predict future unemployment rates. The consistency of this outcome across lag 1 (p-value: 0.3742), lag 2 (p-value: 0.0485), and lag 3 (p-value: 0.0686), with chi-squared statistics of 0.8465, 3.6717, and 5.5224 respectively, suggests that, within this dataset and period, gold prices do not Granger-cause changes in unemployment.

In the pursuit of deeper insights into the intricate relationship between the price of gold and the unemployment rate, a progressive step was taken by employing a polynomial regression model. This advanced analytical approach was applied to a meticulously curated scatter plot encompassing the normalized values of the gold price and the unemployment rate on a monthly basis across the EU27 region for the extensive period spanning from 2019 to 2024.

Figure 3 serves as the visual manifestation of this analytical endeavor, offering a comprehensive portrayal of the results obtained from the polynomial regression model. The visualization encapsulates the influence of varying lag periods, ranging from 0 to 6, on the relationship between the price of gold and the unemployment rate. Through this detailed examination, we aim to unravel the underlying dynamics, elucidate causal relationships, and provide valuable insights into the intricate interplay between these pivotal economic indicators.

Figure 3 The regression analysis for gold price and rate of unemployment in EU 27 (monthly 2019-2024 year)



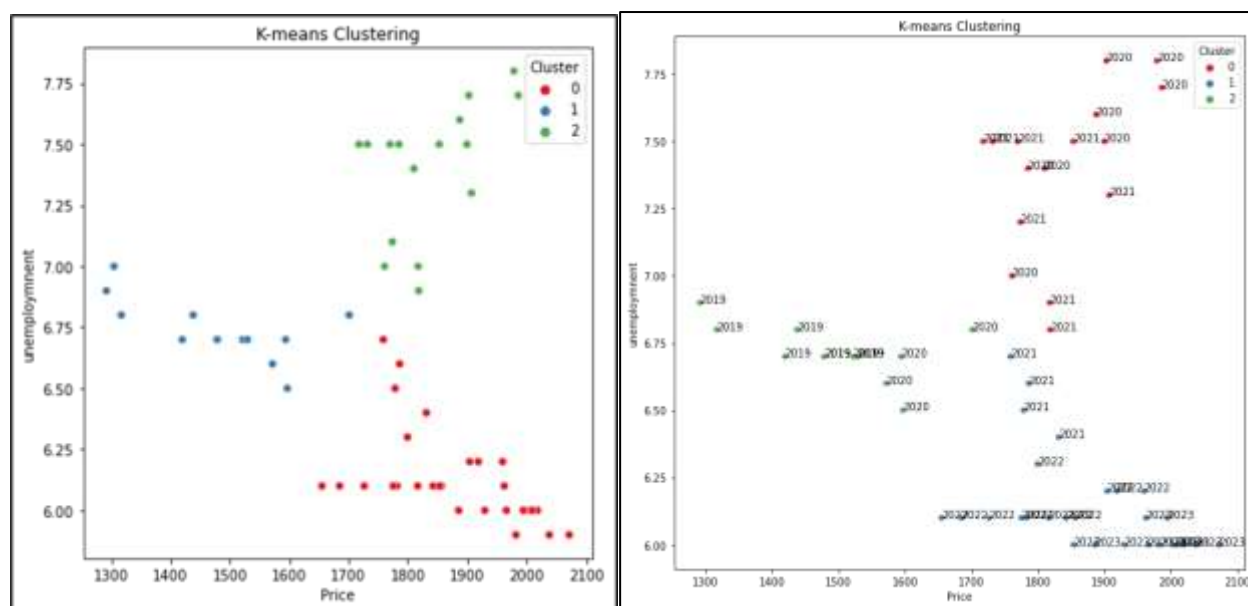
Source: European commission and own calculations.

Figure 3 unveils the outcomes derived from the regression analysis, providing a visual representation of the findings. Notably, the coefficient of determination (R^2) spans a range from 0.1 to 0.6, indicating a notable variability in the degree of regression dependence. This observation prompts a critical inquiry into the absence of a confirmed regression relationship despite the inherent logical connection between the price of gold and the unemployment rate.

The discrepancy between the anticipated relationship and the empirical findings underscores the complexity inherent in economic phenomena. To delve deeper into this enigma, our analysis ventures into k-means clustering, a robust technique employed for pattern detection and classification within datasets. By clustering the values derived from the data, we aim to discern latent patterns and uncover underlying structures that may elucidate the observed divergence from expectations.

Figure 4 serves as the visual manifestation of this analytical progression, offering insight into the clustered patterns discerned through k-means clustering. This methodology holds the promise of unraveling hidden relationships and shedding light on the intricate interplay between the price of gold and the unemployment rate. Through this multifaceted approach, we endeavor to unravel the complexities of economic dynamics and provide valuable insights to inform decision-making processes.

Figure 4. The Cluster Causality analysis for gold price and rate of unemployment in EU 27 (monthly 2019-2024 year)



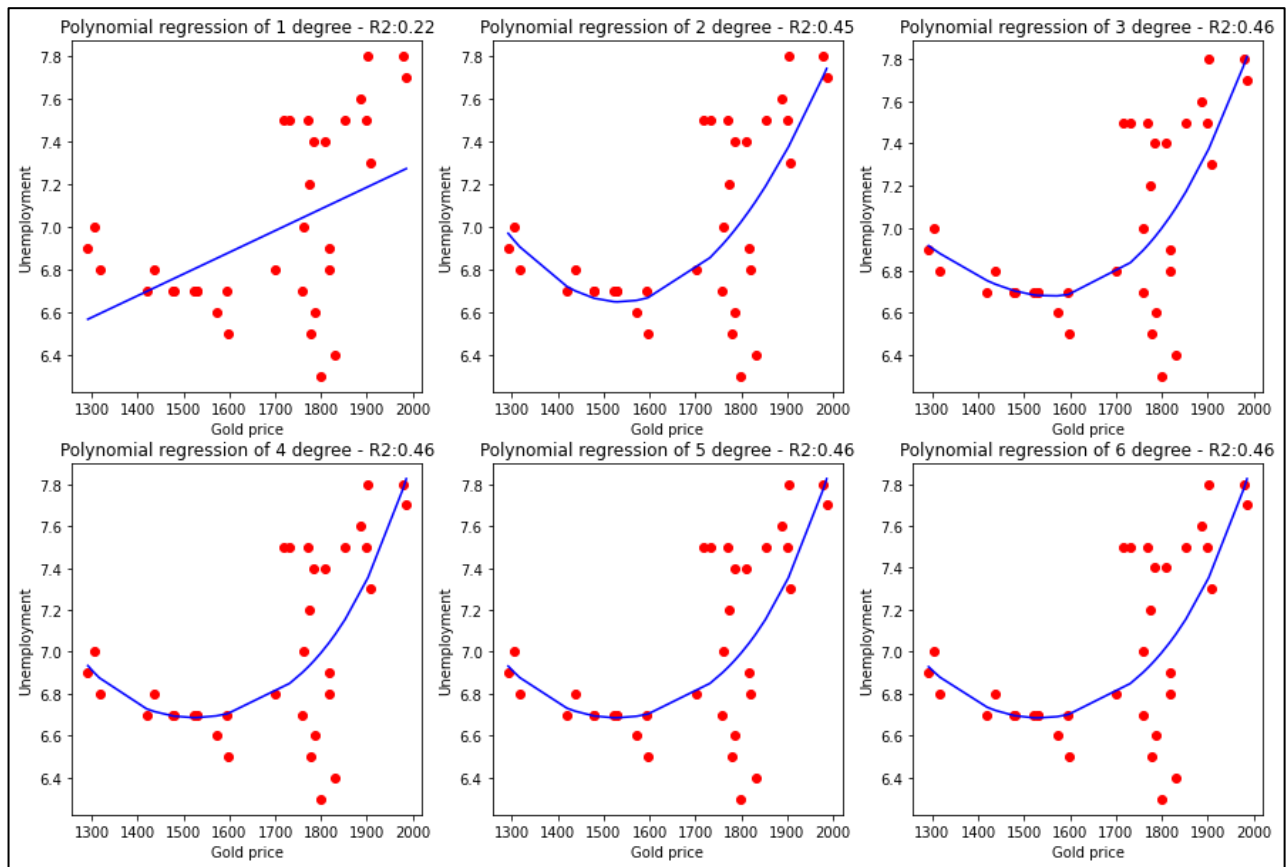
Source: Own calculations.

The results of Fig. 4 show something very interesting and important. First, clustering was done with 3 cluster centers, which very visibly describes the distribution of years between the values of the gold price and the unemployment rate. Upon looking closer, we see that Cluster 3 covers the years from 2019 to 2020, Cluster 1 has data from 2020 to late 2021, and Cluster 2 includes the latter part of 2021, along with 2022 and 2023 year.

It's important to note the strong connection between the war in Ukraine and the years from 2022 to 2024. This war had a big impact on the economy. To make sure our analysis isn't affected by this external event, we decided to leave out the years 2022 to 2024. This helps us focus better on understanding how the price of gold and unemployment are related.

Figure 5 shows what we found after doing the regression analysis without the years 2022 to 2024. This analysis gives us a clearer picture of how the price of gold and unemployment are connected, without being influenced by outside events.

Figure 5. The Regression analysis for gold price and rate of unemployment in EU 27 (monthly 2019-2021 year)



Source: European commission and own calculations.

The insights from Figure 5 underscore the effectiveness of the regression analysis in finding the relationship between the price of gold and the unemployment rate across the EU27 on a monthly basis. Notably, this analysis proves robust even when the influence of external factors, such as the war in Ukraine, is removed from consideration.

Of particular significance is the coefficient of determination (r^2), which serves as a key metric in evaluating the explanatory power of the regression model. At a power of 2, the coefficient of determination stands at 0.45, indicating that the model accounts for approximately 45% of the variance in the relationship between the price of gold and the unemployment rate. As we increase the power, we observe a slight uptick in the coefficient of determination, reaching 0.46. While this increase may seem marginal, it signifies a nuanced improvement in the model's ability to explain the variability in the data.

5. Conclusion

The relationship between gold and unemployment is intricate and multifaceted, influenced by a variety of economic, political, geostrategic, and environmental factors. During economic crises and

periods of rising unemployment, increased demand for gold as a safe-haven asset tends to raise its value, as investors bolster their positions in gold to diversify their portfolios. Additionally, the ongoing green transition and rising interest in sustainable investments introduce new dynamics to this relationship, as investors increasingly consider assets aligned with green economics. These emerging sustainable assets may influence the traditional demand for gold, particularly during periods when green investments present alternatives aligned with environmental priorities. Granger causality tests provided insights into whether changes in gold prices precede changes in unemployment rates or vice versa, while regression analysis was used to model the nonlinear relationship between the two variables. Initially, our results did not confirm the presence of a statistically significant relationship between gold prices and unemployment levels within the study period. However, after accounting for external events, such as the war in Ukraine and the green transition initiatives, which could potentially distort the data, we conducted a polynomial regression analysis that offered deeper insights into the examined relationship. Isolating external shocks and events revealed that exogenous factors—including geopolitical conflicts and sustainability trends—can obscure the underlying relationship between gold prices and unemployment levels, leading to distortions in the analysis results. The application of cluster analysis (k-means) identified different periods and market conditions, while time series analysis and the exclusion of external factors helped us more clearly establish the link between gold and unemployment. Nonetheless, the determined value of the coefficient of determination indicates that around 45% of the variations in the data can be explained by the model, with this percentage slightly increasing to 46% with a higher degree of regression. Our findings suggest that while gold plays a key role as a stable asset during economic crises, inflation, geopolitical conflicts, and periods of uncertainty, exogenous factors—including those related to the green transition—significantly influence its value and unemployment levels. This analysis highlights the need for a multifaceted approach that integrates both economic and environmental trends to establish market dynamics and make informed investment decisions. Investors using gold as a hedging tool or for portfolio diversification must consider not only traditional economic indicators but also sustainability factors and the ongoing shift toward green investments, underscoring the importance of understanding how both environmental and economic shifts may impact traditional asset behaviors and macroeconomic indicators.

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