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CERTIFICATE

This is certified that the project paper entitled “A Study of Gold Prices and Consumer Price Index (CPI) of UK during 1980 – 2020 and the Correlation Between Them” submitted by Debanjan Das in fulfillment of the requirements for the Bachelors Degree of Statistics Honors is based upon the result of benefited research work carried out by the investigator under my guidance and supervision.

The results of the investigator reported in this project paper have not so far been submitted for any degree or diploma.

Signature

_____

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DECLARATION

I, Debanjan Das, a student of B.Sc. Semester – 6, Statistics Honors, of West Bengal State University, Registration Number – 1012011400109, Roll – 6241130, No. – 21937, hereby declare that I have done this piece of project work entitled as "A Study of Gold Prices and Consumer Price Index (CPI) of UK during 1980 – 2020 and the Correlation Between Them" under the supervision of Dr. Arabinda Das (H.O.D. Department of Statistics, Archarya Prafulla Chandra College) as a part of B.Sc. Semester 6 examination according to the syllabus paper STSADSE06P.

I further declare that this piece of project work has not been published elsewhere for any degree or diploma or taken from any published project.

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(Signature of the Student)

A STUDY OF GOLD PRICES AND CONSUMER PRICE INDEX (CPI) OF UK DURING 1980 – 2020 AND CORRELATION BETWEEN THEM

CONTENTS

Summary

Gold has been, for the longest of time, treated as the safe haven asset and hence during periods of uncertainty this generally is the first area of investment. As a result, the prices also shoot up. While there are various possible factors which might affect the movement in the price of gold, like, changes in macro forces (demand and supply), inflation, interest rate, international prices or exchange rate and times of crisis. The paper aims at first trying to forecast the gold prices from the data available and also check if there is an interdependence between the gold prices and the CPI. If the relationship holds, it would be easier, as compared to now, to predict the trends/fluctuations in the gold prices.

Firstly, trying to fit a best fit curve for the gold prices and predicting the future gold prices, we see that the trendline is polynomial of degree 2. Using the seasonal variation, we get that the middle months of the year experiences a decline in the gold prices, while other times it increases. This might be due to the festive season in the later part of the year and in the beginning due to a lag in the demand and price change, it takes time for the gold prices to come down. Prominent cyclical trends can also be seen in the data.

Considering the CPI next, we get that the CPI has a positive linear relationship with time. Hence as time passes, the CPI tends to increase. This is an indication that the CPI is increasing at a constant rate and that the UK economy is in a sound position. In the initial months of the year (Jan-Feb), the CPI is low as compared to the later years due to the festive season that starts around March and continues more or less until December. However, for the CPI trend, we see that there is no cyclicality, implying the growth is smooth throughout.

Using the trend obtained, we have also tried forecasting the gold price and CPI series for future.

Finally, when we try analyzing if there is a significant relationship between the gold prices and CPI, we get the trend to be a polynomial one of degree 2. Hence initially there is more or less no relationship, but after a point of time, positive relation is witnessed.

SECTION 1: INTRODUCTION

Gold is one of the most popular metals worldwide due to its security and long run high demand. It is often used as an investment arena since it preserves the purchasing power in the long run.

Gold has been a multipurpose metal, which is used in industries like medical, technological, aerospace, etc. along with the intrinsic value that it already has. For instance, gold plated stents are used to help support weak blood vessels because of the best visibility under x-ray, used in connectors, switches, connecting wires as it is an efficient conductor of electricity, multi-layer insulation and metal plating in satellites, etc.

Gold prices are getting a lot of attention because of their potential impact on inflation. Gold is often said to be the best saver of purchasing power in the long run. Gold investments can also be used as a hedge against inflation and devaluation. Therefore, investors are interested in investing in gold because of their economic fragility. From an economic and financial point of view, gold price movements are interesting and important. It is undeniable that gold prices are always stable and that economic and financial fluctuations are kept to a minimum. Gold prices are affected by a variety of factors, including inflation, crude oil, and exchange rates. However, the price of gold can fluctuate significantly due to inflation. Gold prices curb inflationary instability.

Consumer Price Index (Cost of Living Index) is created to examine the impact of price changes on the basket of goods and services on the purchasing power of a particular group of people during the current period compared to the base period. Changes in a person's living expenses between the two periods mean changes in their financial income needed to maintain the same standard of living in both periods.

Therefore, the CPI numbers are intended to measure the average cost increase incurred in a particular year to maintain the same criteria as the baseline. Changes in price levels have different implications for each class, as people's consumption habits vary widely from class to class (eg, poor, low income, middle income, rich, etc.) and even within the same class from region to region. The general price index figures usually do not reflect the impact of changes in general price levels on the cost of living in different sections of the population. Therefore, the Cost-of-Living Index figures are edited to provide a general measure of price fluctuations for commodities consumed by different population groups.

The Consumer Price Index (CPI) is given by the following relation:

$$CPI = \frac{\sum_j p_{ij} q_{0j}}{\sum_j p_{0j} q_{0j}} \times 100$$

$$= \frac{Total\ expenditure\ in\ current\ year\ with\ base\ year\ quantities\ as\ weights}{Total\ expenditure\ in\ base\ year} \times 100$$

where, p_{ij} : $price\ of\ j^{th}\ commodity\ in\ the\ i^{th}\ year,$
q_{0j} : $quantity\ of\ the\ j^{th}\ commodity\ in\ the\ base\ year,$
p_{0j} : $price\ of\ the\ j^{th}\ commodity\ in\ the\ base\ year$

CPI is an indicator of inflation. It measures the percentage change in the price of a basket of goods and services consumed by households. Similarly, the Wholesale Price Index (WPI) measures changes at the wholesale price levels.

To measure inflation, we estimate how much CPI has increased in terms of percentage change over the same period the previous year. If prices have fallen, it is known as deflation.

Economists believe that slow increasing, and predictable inflation is good for an economy.

Gold, due to its almost steady character as compared to currency, holds significant value and is used to hedge inflation. This is why investors prefer to hold gold rather than currency. As a result, when the inflation is high, the demand for gold increases and vice versa. The price of gold will then shoot up as a result of high demand from customers. This holds true for both international inflation as well as that which occurs in UK.

In my project, I have considered to verify if there exist any dependence (interrelation) between the two variables: gold price and CPI, for the country UK, using the monthly data from January 1980 to December 2020. We will also see that how the two variables have changed over the years by performing a time series analysis for both the variables.

SECTION 2: OBJECTIVE

The project aims to majorly predict the gold prices over time. The three objectives covered in this paper are:

1. Checking the time series for the gold prices over a period of time for the UK market to check for trend, seasonality, cyclicality and fitting a trend line, which would be polynomial in nature due to the fluctuations. The gold prices are then forecasted for the future years.

2. Forecasting the CPI in a similar fashion as gold prices.

3. Checking, both graphically and statistically, if there is any correlation between gold prices and CPI. Also using CPI as an independent variable in gold price prediction and analyzing if CPI is a significant factor in determining gold prices.

SECTION 3: DATA

The analysis uses two major variables namely, gold prices and CPI over a period of time that ranges from January 1980 to December 2020, at a monthly frequency for the UK market.

The data description is as follows:

- Gold prices: The unit of gold price is GBP/ounce. In our study this is the dependent or the 'Y' variable.
- Consumer Price Index: The base year considered for the CPI computation is 2015. CPI is one of our independent variables used in the analysis.
- Time: 41 years monthly data has been used for the analysis.

The data has 492 observations in total. To reduce the complexities, the dimension is reduced from months to years, giving a total of 41 years (observations). Hence for every year, we have the averages as the value. The dimensionality reduction would also help in eliminating the seasonal or irregular variations that the data might have.

Now, after the modification of the obtained data, we have 41 time points measured yearly. Let us consider a new time variable t_i such that,

$$t_i = i, \forall\, i = 0(1)40$$

Where t_i's represents the time points of the years, taking t_0 as the origin time point which correspond to the year 1980. Where t_i is the time point for the year $(1980 + i)$.

Similarly, for the variables X and Y, we have the following setup: -

y_i : $Average\ Gold\ Price\ of\ the\ UK\ for\ the\ year\ t_i\ measured\ in\ /oz$;

x_i : $Average\ CPI\ of\ the\ UK\ for\ the\ year\ t_i\ measured\ in\ \%$

where, $i = 0(1)40$.

SECTION 4: THEORIES USED IN THE STATISTICAL ANALYSIS OF THE PROJECT

1. Time Series Analysis of the Data:

A set of ordered observations of a quantitative variable taken at successive points in time is known as 'Time Series'. Such series have a unique important place in the field of Economic and Business Statistics since the data relating to prices, consumption and production of various commodities; money in circulation; bank deposits and bank clearings: sales and profits in departmental store, etc. A time series depicts the relationship between two variables, one of them being time, for example as in this project, the gold price (y_i) of UK and the different years (t_i).

The various forces at work, affecting the values of a phenomenon in a time series, can be broadly classified into the following four categories, commonly known as the components of a time series, some or all of which are present (in a given time series) in varying degrees. The four components are as follows:

(a) Trend or Secular Trend (or, Long-term Movement) $[T_t]$

(b) Periodic Changes (or, Short-term Fluctuations) -

(i) Seasonal Variations $[S_t]$(when period of the fluctuation is less than or equal to a year)

(ii) Cyclical Variations $[C_t]$ (when the period of oscillation is more than a year)

(c) Random or Irregular movements $[I_t]$.

In our study, we have analyzed assuming that the various components of the time series follow a multiplicative model, i.e., we can write a particular variable as:

$$y_t = T_t \times S_t \times C_t \times I_t$$

This assumption is appropriate for our study, since we have an economic data, and economic data tends to conform well with a multiplicative model. The same assumption is made for the variable X also.

2. Estimation of Polynomial Regression Equation by the Method of Least Squares:

Let there be two variables x and y such that they are related. We want to find an equation such that $y = f(x)$, i.e., we want to explain y as a function of x. Here, we consider the following

$$y : Dependent\ variable,\ \ x : Independent\ variable.$$

We have obtained the following bivariate data: (x_i, y_i) , $i = 1(1)n$,

Where, $n : Number\ of\ paired\ observations.$

Since we are using Polynomial Regression, we would assume the following function, i.e., we will assume y as a Polynomial function of x of degree p:

$$y = a_0 + a_1 x + a_2 x^2 + \cdots + a_p x^p$$

Now, we write the Polynomial Regression model as:

$$y_i = a_0 + a_1 x_i + a_2 x_i^2 + \cdots + a_p x_i^p + \epsilon_i , \quad i = 1(1)n.$$

Where $\epsilon_i{}'s$ are the error terms.

Now, to find the exact polynomial we will have to find the estimates of $a_0, a_1, a_2, \cdots, a_p$

Such that:

$$S^2 = \sum_{i=1}^{n} \epsilon_i^2 , is\ minimized\ w.r.t.\ all\ possible\ real\ combinations\ of\ a_0, a_1, a_2, \cdots, a_p .$$

We can rewrite S^2 as:

$$S^2 = \sum_{i=1}^{n} \left(y_i - a_0 - a_1 x_i - a_2 x_i^2 - \cdots - a_p x_i^p\right)^2$$

Now, we treat S^2 as a function of the coefficients $a_0, a_1, a_2, \cdots, a_p$, and minimise w.r.t each of them.

For a_0, we have $\frac{\partial S^2}{\partial a_0} = 0 \Rightarrow (-2)\sum_{i=1}^{n}\left(y_i - a_0 - a_1 x_i - a_2 x_i^2 - \cdots - a_p x_i^p\right) = 0$

$$\Rightarrow \sum_{i=1}^{n} y_i = n a_0 + a_1 \sum_{i=1}^{n} x_i + a_2 \sum_{i=1}^{n} x_i^2 + \cdots + a_p \sum_{i=1}^{n} x_i^p$$

Which is the first normal equation.

Similarly, on partial differentiation of S^2 with $a_k, k = 2(1)p$, we will have :

$$\frac{\partial S^2}{\partial a_k} = 0$$

$$\Rightarrow (-2)\sum_{i=1}^{n}\left(y_i - a_0 - a_1 x_i - a_2 x_i^2 - \cdots - a_p x_i^p\right) \cdot x_i^k = 0$$

$$\Rightarrow \quad a_0 \sum_{i=1}^{n} x_i^k + a_1 \sum_{i=1}^{n} x_i^{k+1} + \cdots + a_p \sum_{i=1}^{n} x_i^{k+p} = \sum_{i=1}^{n} x_i^k y_i \ ; \quad \forall\, k = 2(1)p.$$

Where the above equation represents the k^{th} Normal Equation.

We now write the (p+1) normal equations in matrix form as :-

$$\begin{pmatrix} n & \sum_{i=1}^n x_i & \sum_{i=1}^n x_i^2 & \cdots & \sum_{i=1}^n x_i^{\,p} \\ \sum_{i=1}^n x_i & \sum_{i=1}^n x_i^{\,2} & \sum_{i=1}^n x_i^3 & \cdots & \sum_{i=1}^n x_i^{p+1} \\ \sum_{i=1}^n x_i^2 & \sum_{i=1}^n x_i^3 & \sum_{i=1}^n x_i^4 & \cdots & \sum_{i=1}^n x_i^{p+2} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \sum_{i=1}^n x_i^{\,p} & \sum_{i=1}^n x_i^{p+1} & \sum_{i=1}^n x_i^{p+2} & \cdots & \sum_{i=1}^n x_i^{2p} \end{pmatrix} \cdot \begin{pmatrix} a_0 \\ a_1 \\ a_2 \\ \vdots \\ a_p \end{pmatrix} = \begin{pmatrix} \sum_{i=1}^n y_i \\ \sum_{i=1}^n x_i y_i \\ \sum_{i=1}^n x_i^2 y_i \\ \vdots \\ \sum_{i=1}^n x_i^{\,p} y_i \end{pmatrix}$$

$$\Longrightarrow A \cdot b = c, (say)$$

Then, $b = A^{-1}.c, when\ A\ is\ non-singular, i.e., \det(A) \neq 0.$

Hence, we can say that the solution to the above matrix equation gives us the estimates of the coefficients. We write the estimates as $\widehat{a_0},\ \widehat{a_1},\ \widehat{a_2}, \cdots, \widehat{a_p}$.

These obtained estimates will be such that

$$S^2(a_0, a_1, a_2, \cdots, a_p) \geq S^2(\widehat{a_0},\ \widehat{a_1},\ \widehat{a_2}, \cdots, \widehat{a_p})\ \forall\ (a_0, a_1, a_2, \cdots, a_p) \in \mathbb{R}^p$$

Note that, the $\overline{p+1} \times \overline{p+1}$ Hessian matrix:

$$\begin{pmatrix} \frac{\partial^2 S^2}{\partial a_0^2} & \frac{\partial^2 S^2}{\partial a_0 \partial a_1} & \cdots & \frac{\partial^2 S^2}{\partial a_0 \partial a_p} \\ \frac{\partial^2 S^2}{\partial a_1 \partial a_0} & \frac{\partial^2 S^2}{\partial a_1^2} & \cdots & \frac{\partial^2 S^2}{\partial a_1 \partial a_p} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2 S^2}{\partial a_p \partial a_0} & \frac{\partial^2 S^2}{\partial a_p \partial a_1} & \cdots & \frac{\partial^2 S^2}{\partial a_p^2} \end{pmatrix} \ is\ a\ positive\ semi\ definite\ (p.s.d)\ matrix$$

Hence, the second order condition for the existence of minimum is automatically satisfied. Therefore, the estimates we get on solving the equation $A \cdot b = c$ are the estimates such that S^2 is minimised.

This exact method is used in the estimation of Trend equation of X and Y.

3. Calculation of Correlation Index (R_p^2) of a p^{th} degree Polynomial Regression:

In case of a regression based on a polynomial of p^{th} degree ($p \leq n-1$).

Where there are n observations. Then we can define a measure of association, similar to $|R|$, called the correlation index of the p^{th} order – say, R_p^2 – by:

$$R_p^2 = \frac{Var(Y_p)}{Var(y)} = \frac{\sum_i (Y_{pi} - \overline{Y_p})^2}{\sum_i (y_i - \overline{y})^2}$$

Where Y_{pi} is the predicted value of y as obtained from its p^{th} degree polynomial, its regression equation corresponding to $x = x_i$, and y_i are the obtained values of y.

Where the polynomial equation is :

$$y = a_0 + a_1 x + a_2 x^2 + \cdots + a_p x^p$$

R_p^2 ranges from 0 to 1, the closer R_p^2 is to 1 the more closely the polynomial fits the given data.

4. Reduction of yearly Trend Equation to monthly Trend Equation:

Suppose the yearly trend equation based on yearly totals is:

$T_t = a_0 + a_1 t + \cdots + a_p t^p$ ..... (i),
$with\ origin\ of\ t\ at\ 1980\ (for\ example) and\ unit\ 1\ year.$

To obtain the monthly trend equation, we are to divide the constants by 12 and replace

t by $t/12$. Then the trend equation for monthly values becomes :

$$T_t = \frac{a_0}{12} + \frac{a_1}{12} \cdot \frac{t}{12} + \cdots + \frac{a_p}{12} \cdot \left(\frac{t}{12}\right)^p \quad \cdots\cdots\cdots\cdots (ii)$$

Now, the origin of the above equation is in the middle of 1980. But monthly trend values should correspond to the midpoints of months. For proper centering, the origin should be shifted half a month to the right or to the left. If we want to the right, i.e., to the middle of July, 1980, we have to write $\left(t + \frac{1}{2}\right)$ for t and for left, i.e., to the middle of June, 1980, $\left(t - \frac{1}{2}\right)$ for t in (ii). Note that in this project we want the origin of the monthly trend equation to be in the middle of January, 1980, i.e., for the month of January, 1980, then we have to write $(t - 5.5)$ for t.

Also, note that this reduction is based on the trend equation of yearly totals, but in our project, we have calculated the trend equation for yearly average, hence to get the appropriate monthly trend equation we have to multiply the complete equation by 12.

Finally, we write the appropriate monthly trend equation:

$$T_t = 12 \times \left\{ \frac{a_0}{12} + \frac{a_1}{12} \cdot \frac{1}{12} \cdot (t - 5.5) + \cdots + \frac{a_p}{12} \cdot \frac{1}{12^p} \cdot (t - 5.5)^p \right\}$$

$$\Rightarrow \; T_t = a_0 + a_1 \cdot \left(\frac{t - 5.5}{12} \right) + \cdots + a_p \cdot \left(\frac{t - 5.5}{12} \right)^p$$

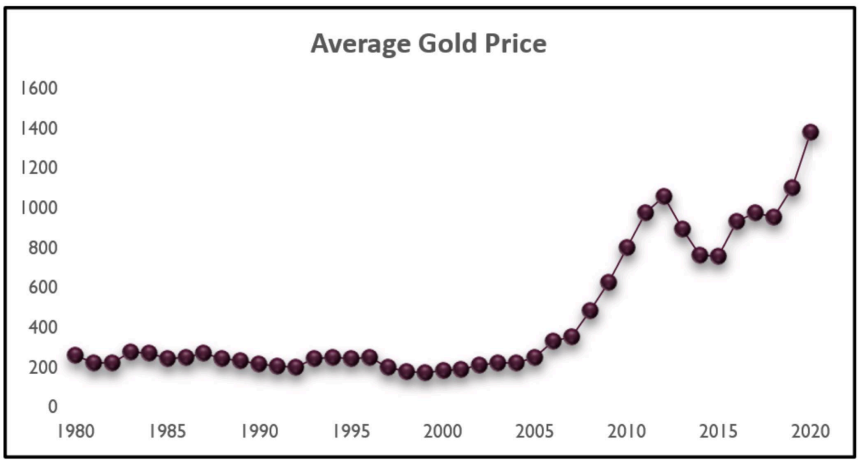
$$with, origin : \; middle\ of\ January\ 1980, \;\; unit\ of\ t : 1\ month$$

5. Ratio to Trend Method for Calculation of Seasonal Variation:

In this method, we first find an appropriate equation to determine trend values for various months. At the next step, we divide the original data month by month by the corresponding trend values and express them as percentages. The different values for a month are then averaged, as in the previous method. And, finally, these averages are adjusted to a total of 1200. It may be noted that in this method we are trying to eliminate the irregular and cyclical variations by averaging. So, this method is recommended for use either when cyclical variation is known to be absent or when it is not so pronounced even if present.

SECTION 5: GRAPHICAL REPRESENTATION OF THE SERIES

1. **Average gold prices in the UK**

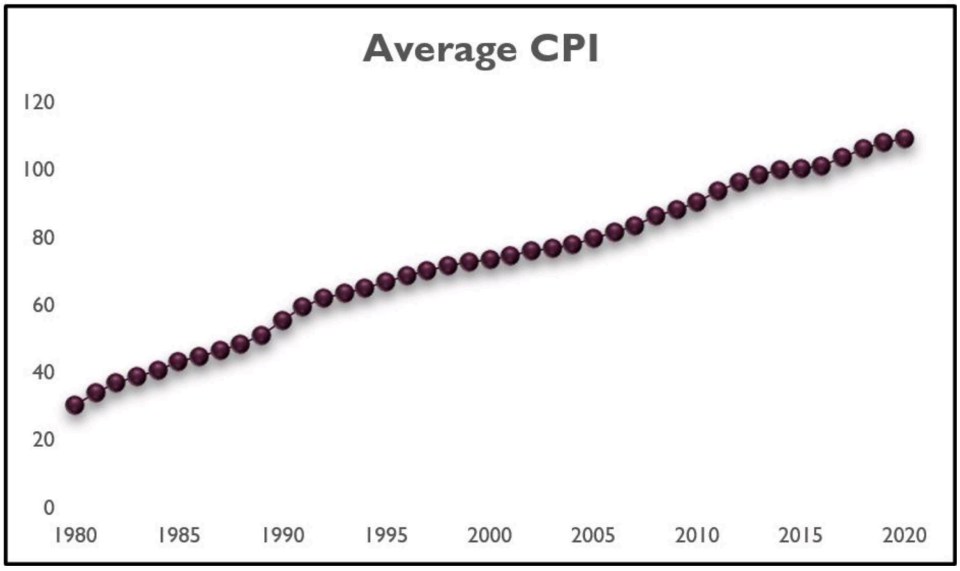


Graph 1: Average Gold Prices in the UK over time (1980-2020)
Source: Kaggle

Here we see that, on an average, the prices were stable from 1980 until 2005, post which a huge jump in the prices can be seen. This happened because of the agreement to limit gold

sales by 15 European Central banks which lead to an increase in demand by investors. Also, the war speculations with Iraq lead to currency depreciation and thus increase in gold prices.

2. Average Consumer Price Index (CPI) in the UK

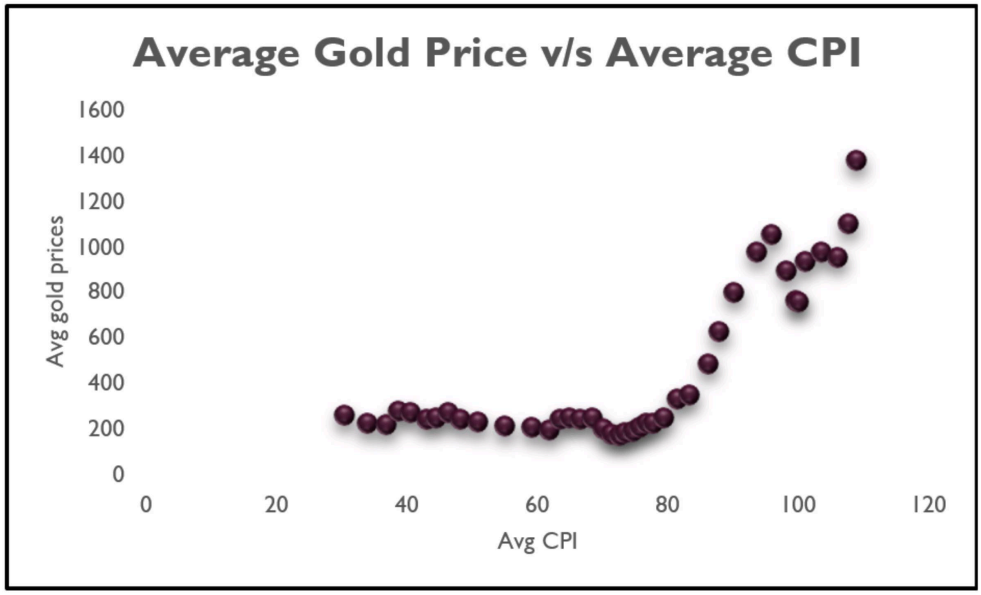


Graph 2: Average CPI in the UK over time (1980-2020)
Source: OECD

Here it can be seen that the UK's CPI has been always following an increasing trend. This implies that there has been constant inflation experienced by the UK economy. Here the rate of inflation has been around 3% on an average, which shows that an economy was progressing at acceptable pace.

3. Average Gold price v/s Average Consumer Price Index (CPI) in the UK

Here we infer that at lower levels of average CPI (<=80), the gold prices have remained almost stable. However, beyond the level, the average gold price shoots up manifold. So, we can say that beyond a threshold, the two variables are positively correlated.



Graph 3: Average gold prices against the average CPI for the UK

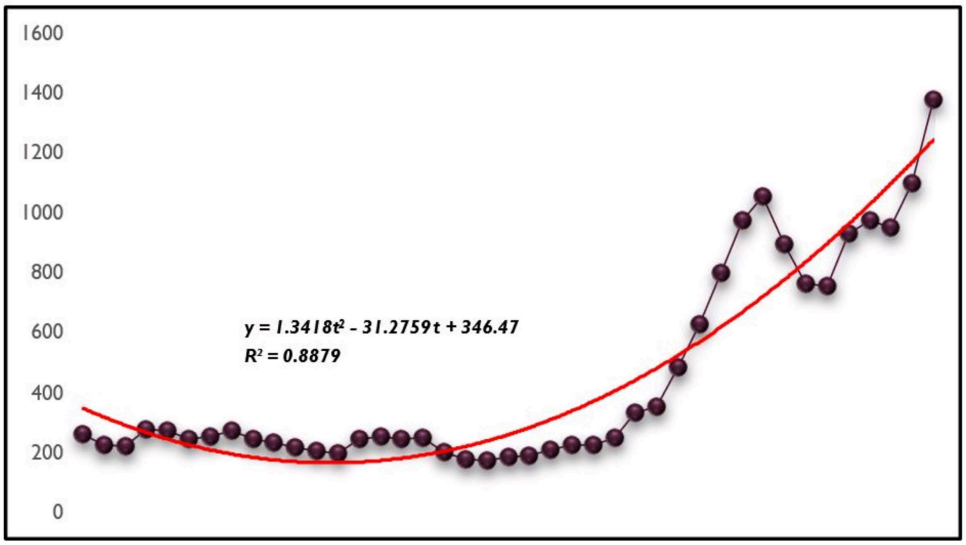
SECTION 6: TIME SERIES ANALYSIS

6.1: GOLD PRICES

- *Secular Trend Analysis*:

  To check if a variable has a consistent pattern within a given time period, secular trend analysis is done.

  Fitting the best fitting line to the gold prices, we get



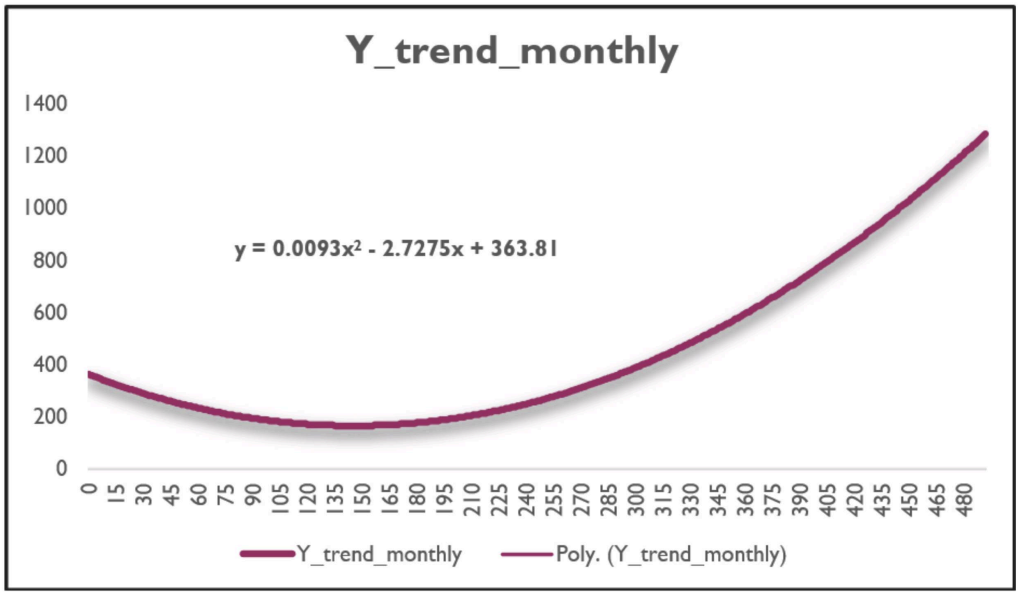
Graph 4: Trend line for the gold prices

From the graph we see the best fit line for the model is a second order polynomial curve. The trend equation is:

$$Y = 1.3418t^2 - 31.2759t + 346.47$$

with the goodness of fit as 88.79%. This is close to 1 implying good deal of the variation in the series has been captured. There are a few extreme points in here, which might be the result of seasonal and cyclical variations.

For checking for the seasonal trend, now the monthly trend has to be checked. Hence, we will apply appropriate adjustments to change the yearly trend equation of Y to monthly trend equation of Y.



Graph 5: Monthly trend of the gold prices using the polynomial equation

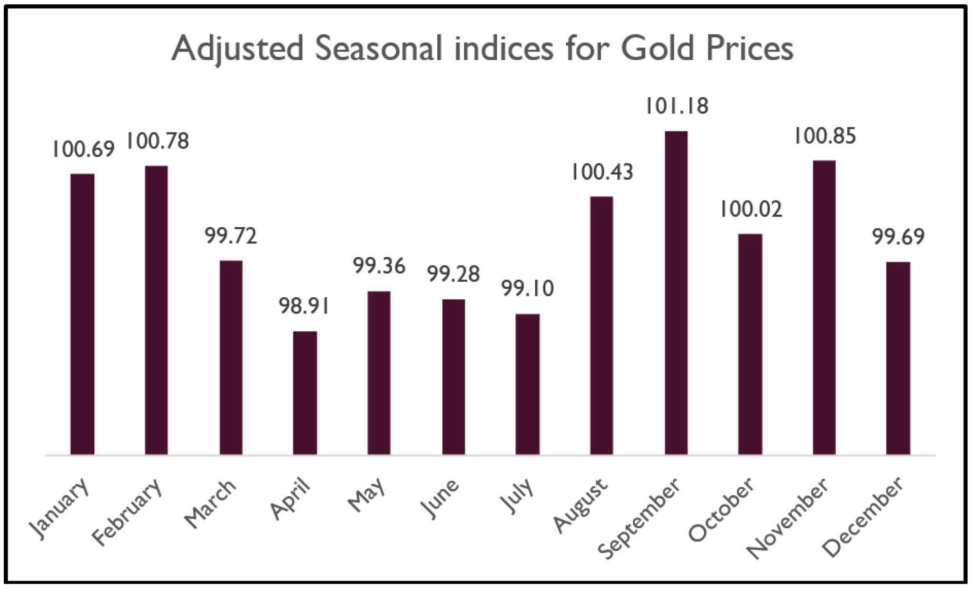
In the above graph, a particular value of $t = t_a$, corresponds to the $(t_a mod(12) + 1)\ th$ month of the year $\left(1980 + \frac{t_a - t_a mod(12)}{12}\right)$. Where the origin of t is at $t = 0$ corresponding to the month of January, 1980.

- *Seasonal Variation Analysis*:

Using the Ratio to Trend method for seasonal indices calculation, we get the following seasonal indices of Gold Prices:

Month	Adjusted Seasonal indices	Seasonal ratios
January	100.69	1.0069
February	100.78	1.0078
March	99.72	0.9972
April	98.91	0.9891
May	99.36	0.9936
June	99.28	0.9928
July	99.10	0.9910
August	100.43	1.0043
September	101.18	1.0118
October	100.02	1.0002
November	100.85	1.0085
December	99.69	0.9969

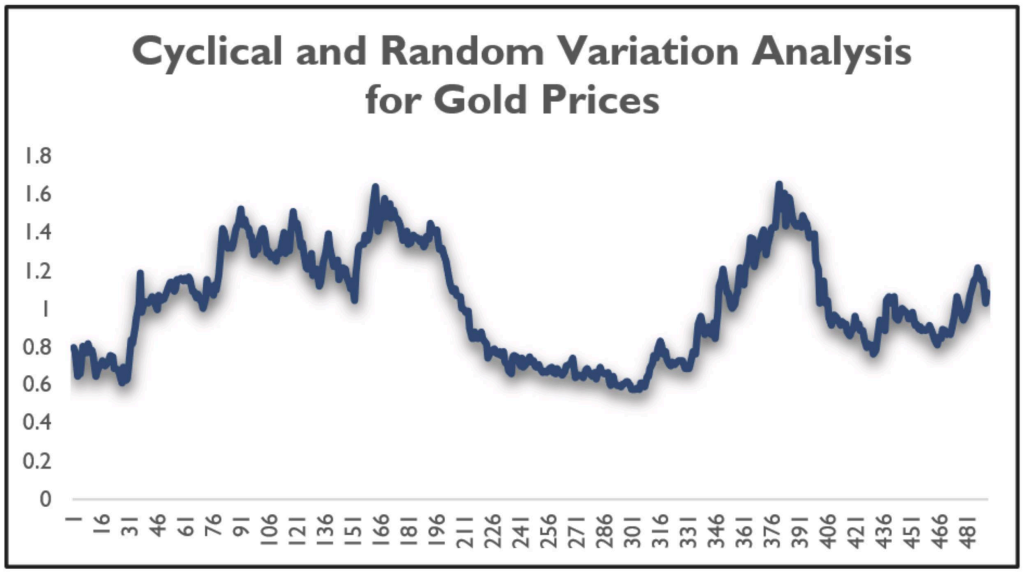
Table 1: Seasonal indices and Seasonal ratios for the gold prices



Graph 6: Adjusted Seasonal indices for Gold Prices

From the table we understand that the extreme months of a year has higher price as compared to the mid months. This might be because of the festive season, when the demand is high, leading to an increase in the price.

- *Cyclical and Random Variation Analysis*



Graph 7: Cyclical and Random Variation Analysis for Gold Prices

Here we see prominent cyclical trend throughout where until period 193 it had an increasing trend, post which there has been a decline. An upward trend is again witnessed post period 307.

6.2: CONSUMER PRICE INDEX

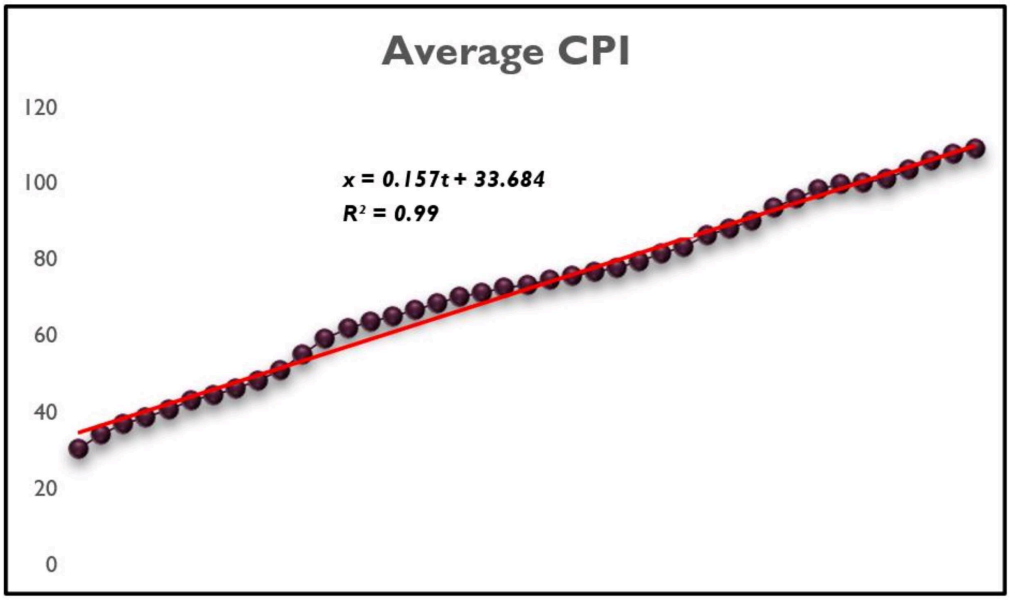
- *Secular Trend Analysis*:

For the average CPI, a linear trend can be seen for the scatter plot. Hence, the trendline we get is an upward sloping linear curve:

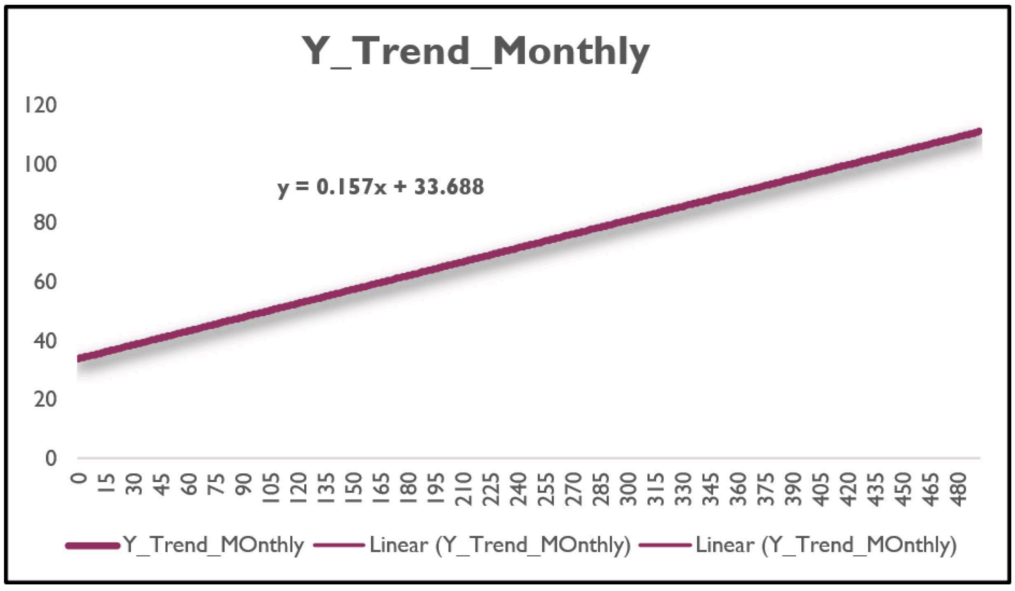
$$x = 0.157t + 33.684.$$

We get the R^2 as 99% which is very close to 1. The equation for the best fit line is $x = 0.157t + 33.684$, where x is CPI and t is the time. Here there are few areas where the actual deviates from the trendline which might be because of the seasonal and/or cyclical trends.

For calculating the season trend, we compute the monthly trend for CPI. Hence, we will apply appropriate adjustments to change the yearly trend equation of CPI to monthly trend equation of CPI.



Graph 8: Trend line for CPI



Graph 9: Monthly trend of CPI using the linear equation

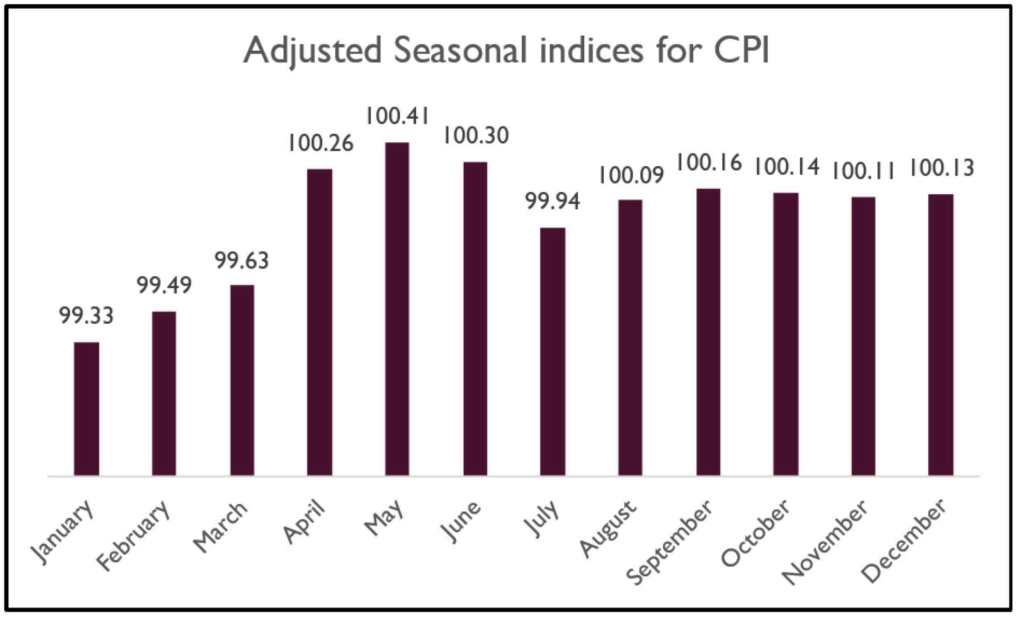
In the above graph, a particular value of $t = t_a$, corresponds to the $(t_a mod(12) + 1)\ th$ month of the year $\left(1980 + \frac{t_a - t_a mod(12)}{12}\right)$. Where the origin of t is at $t = 0$ corresponding to the month of January, 1980.

- *Seasonal Variation Analysis*:

Using the Ratio to Trend method for seasonal indices calculation, we get the following seasonal indices of CPI:

Month	Adjusted Seasonal indices	Seasonal ratios
January	99.33	0.99326
February	99.49	0.99494
March	99.63	0.99632
April	100.26	1.00226
May	100.41	1.00407
June	100.30	1.00301
July	99.94	0.99944
August	100.09	1.00093
September	100.16	1.00160
October	100.14	1.00136
November	100.11	1.00112
December	100.13	1.00126

Table 2: Seasonal indices and Seasonal ratios for the CPI

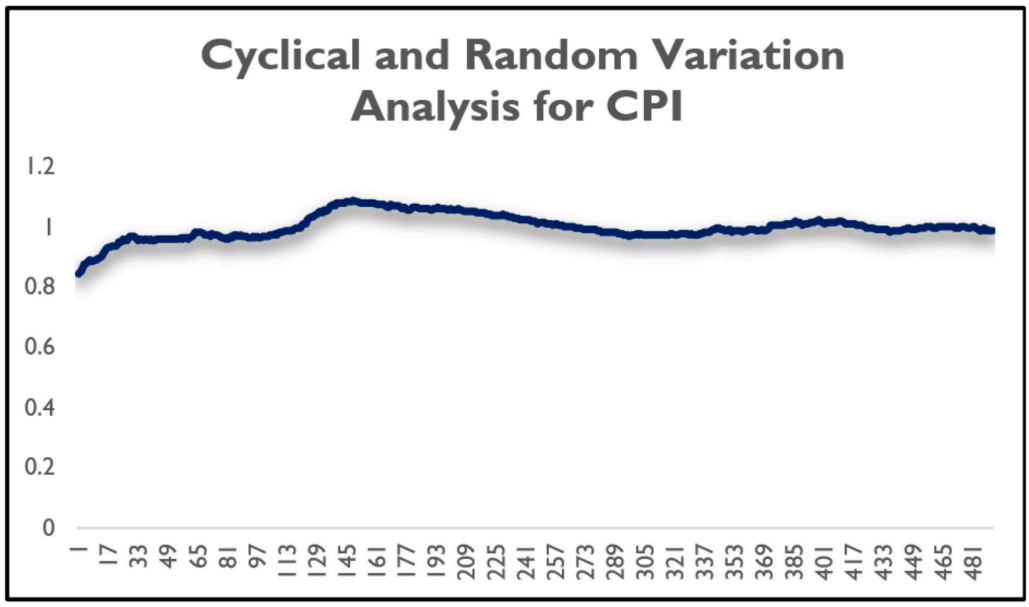


Graph 10: Adjusted Seasonal indices for CPI

From the above table we see that almost throughout the CPI has had an increasing trend, except for January and February. This might be because the festive season gets over in the UK by end of

December and they cut down on expenditure, or rather start saving, for the first two months until festive season is back in around March (festive season restarting with Easter).

- *Cyclical and Random Variation Analysis*



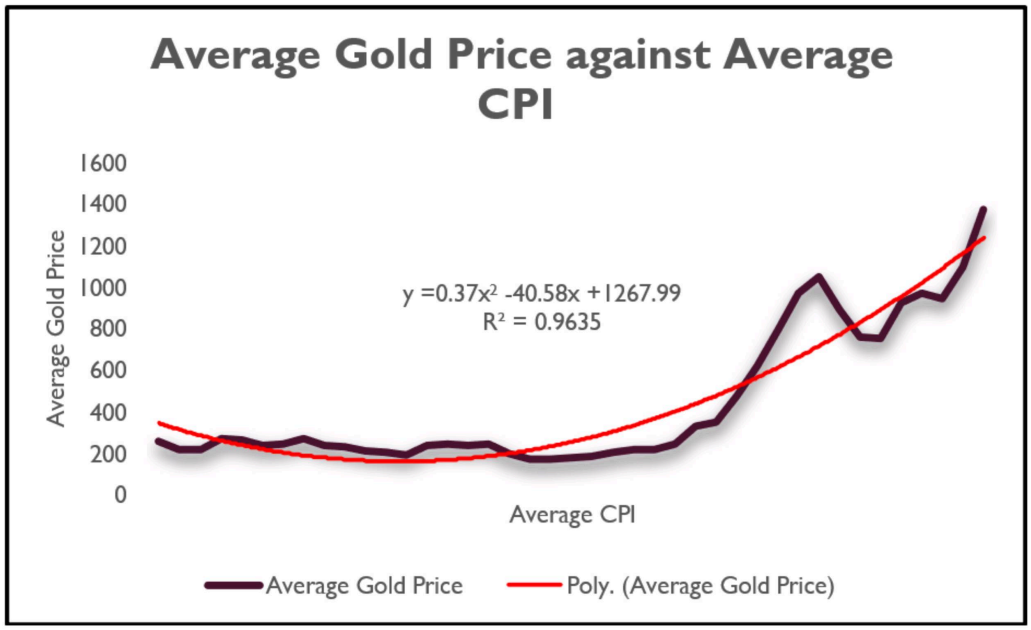
Graph 11: Cyclical and Random Variation Analysis for CPI

Here, from the graph, it can be clearly seen that there are no major variations, implying there is no cyclical trends present in the data.

6.3: REGRESSION OF GOLD PRICES ON CPI

The next step in our analysis is to check if the fluctuations in CPI causes a change in the gold prices. Here we fit a second-degree polynomial as the best fitting line for the relationship.

The R^2 for the set model is around 97%, which explains fair deal of fluctuations in gold prices due to changes in CPI. From the curve we get that at the lower level of CPI, the two variables have a more or less stable relation. However, after a certain point, we see, as CPI increases, it leads to an increase in the gold prices.



Graph 12: Average Gold Price against Average CPI

Forecasts: -

We want to forecast the values of Gold Price and CPI for the next year, i.e., 2021 for all months.

Firstly, let us calculate forecasts based on our time series analysis. Hence, the table below shows the forecasts of Gold Price and CPI based on our time series analysis.

[Note that – the forecasts using the time series analysis will be calculated using the following equation: $Y_t = T_t \times S_t$.]

Date	*Time point(t)*	*Forecast of Gold Price Based on Time Series Analysis (y_t)*	*Forecast of CPI Based on Time Series Analysis (x_t)*
21-Jan	492	1,281.87	110.19
21-Feb	493	1,289.50	110.53
21-Mar	494	1,282.31	110.84
21-Apr	495	1,278.32	111.70
21-May	496	1,290.67	112.01
21-Jun	497	1,295.98	112.05
21-Jul	498	1,300.15	111.81
21-Aug	499	1,324.19	112.14
21-Sep	500	1,340.68	112.37
21-Oct	501	1,331.85	112.50
21-Nov	502	1,349.55	112.63

21-Dec	503	1,340.72	112.80

In the above table, the following trend equations are used:

Next let use the forecasts of CPI to predict the Gold Prices for the year 2021 for all months, using the polynomial regression equation as shown in Fig 10. The table below shows the obtained forecasts:

1. y = 0.0093x2 - 2.7275x + 363.81

2. y = 0.157x + 33.688

Date	**Forecast of CPI Based on Time Series Analysis (x_t)**	**Forecast of Gold Price Using the Regression Equation of Gold Price on CPI (Y_x)**	**Forecast of Gold Price Based on Time Series Analysis (y_t)**
21-Jan	110.19	1,269.15	1,281.87
21-Feb	110.53	1,283.09	1,289.50
21-Mar	110.84	1,295.79	1,282.31
21-Apr	111.70	1,331.29	1,278.32
21-May	112.01	1,344.63	1,290.67
21-Jun	112.05	1,346.30	1,295.98
21-Jul	111.81	1,336.14	1,300.15
21-Aug	112.14	1,349.75	1,324.19
21-Sep	112.37	1,359.53	1,340.68
21-Oct	112.50	1,365.03	1,331.85
21-Nov	112.63	1,370.57	1,349.55
21-Dec	112.80	1,377.91	1,340.72

In the above table, Y_x is calculated with the equation:

y =0.37x2 - 40.58x +1267.99

SECTION 7: CONCLUSION

From the analysis we conclude that on the basis of forecasts, CPI can be considered to be a good predictor of Gold Prices in the US. We get that both the CPI and Gold Prices have an increasing trend but at a stable rate. Here the forecasts might change over time due to idiosyncratic factors which would affect the world as a whole and also systematic factors, which would affect the UK economy only.

Overall, it can be seen that the Polynomial Equations predict the CPI and Gold Prices quite well. Hence, we can take the same into consideration for forecasting the future numbers.

However, given that it does not consider any other socio-economic factor, the actuals might differ from the predicted. Hence one suggestion here can be considering some economic factors for better predictions.

We also see that the estimates y_t and Y_x are quite close to each other at the earlier part of the year 2021 but the difference between them increases rapidly after April 2021, this may due to the effect of cyclical and irregular variation. Due to these variations the time series forecasts of Gold Price become lower than the forecasts obtained from the regression equation of Gold Price on CPI.

SECTION 8: BIBLIOGRAPHY

The following websites were utilized to make the project: -

- www.wikipedia.org
- www.mecmining.com
- www.gold.org
- www.bankbazaar.com

The books used to develop the theories that are used in the project: -

- Fundamentals of Statistics Vol.1 – A.M. Gun, B.K. Gupta, B. Dasgupta
- Fundamentals of Statistics Vol.2 – A.M. Gun, B.K. Gupta, B. Dasgupta
- Statistical Tools and Techniques – P.K. Giri, J. Banerjee
- Fundamentals of Applied Statistics – S.C. Gupta, V.K. Kapoor

The data used in this project was obtained from the following websites: -

- www.kaggle.com
- https://fred.stlouisfed.org/

All the graphs and calculations done in this project is done using the software Microsoft Excel.