Journal of Computing Research and Innovation (JCRINN) Vol. 6 No. 1 (2021) (pp91-99)
https://jcrinn.com : eISSN: 2600-8793
https://doi.org/10.24191/jcrinn.v6i1.186

Application of FAHP in Gold Price Fluctuation Factor Evaluation

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Received Date: 18 October 2020
Accepted Date: 12 November 2020
Revised Date: 20 December 2020
Published Date: 1 January 2021

HIGHLIGHTS

- Fuzzy Analytic Hierarchy Process was used to evaluate and ranking the factor of gold price fluctuation.
- The primary data on the factors of volatility of gold price have been determined by experts.
- The factors of gold price fluctuation such as currency exchange, demand, inflation and mining were ranked.
- The most important factor that affects the volatility of gold price was the currency exchange.

ABSTRACT

Gold has become one of the most popular and secures type of investment in our country. However, the price of gold shows a high level of volatility. This paper aims to explore the use of Fuzzy Analytic Hierarchy Process (FAHP) in evaluating and ranking the Malaysian gold price fluctuation factors. Nevertheless, there are not many researches have been done on FAHP method in gold price analysis. The strength of FAHP method is its application in solving the problem of selecting something that is inaccurate or uncertain. Hence, FAHP as tools of measurement have been applied to evaluate, compare, and rank the gold price fluctuation factors. Specifically, four factors that contribute to the volatility of gold price are determined from experts. The factors are currency exchange, demand, inflation and mining. The evaluation of FAHP shows that the highest value of normalized weight was 0.6892 for the currency factor. This study concludes that the most important factor that affects the gold price change is the currency exchange.

Keywords: *gold price, fuzzy, analytic hierarchy process, factors*

INTRODUCTION

Gold has been one of the important components of investment in today's free-market economy including Malaysia. This is because the price of gold is determined based on the world's market value and it is not affected by the country's economic state. However, the price of the gold shows a high level of volatility. This means that the price of gold can increase or decrease at any time. When the volatility of the price increases, the risk of the securities will also increase. The volatility may be because of the variance or standard deviation that is not constant. Besides that, it may also result from an unexpected event that

occurs in the economy such as inflation and the currency exchange. The increase and decrease in gold's price may affect the decision making of the investors.

Looking at the importance of gold investment, the factors that contribute to the fluctuation of gold price need to be identified. One of the factors is the inflation (Sindhu, 2013). The high level of inflation in a country is proportional to the country currency value and also the price of goods and services. Thus, the price of gold will fluctuate. Aside from this, there are other factors that influenced the gold price to undergo changes such as the oil price, silver price, the currency exchange, investment, demand and production (Mardhiah et al., 2019).

Said & Imad (2009) employ Kaufmann-Winters model by considering factors reflecting gold supply and demand as well as a proxy for stock market (1971–1998). Their study found that gold price was primarily determined by the level of central banks' sales of gold reserves, stock market activities, the value of the US dollar and gold production-fabrication forces (1990–2001). It's also indicates that the factors that impacted gold price in the 1980s were different in the 1990s.

Lili & Diao (2013) have done a study in New York and found that the effect of gold reserve and prices of energy product have a positive correlation to the gold price. They were applied the FAVAR model to analysis factors influencing gold price and the trend of gold price. Sahaida et al. (2017) analysed the macroeconomic factors influencing gold prices of the largest gold consumer in the world (India, China, United States, Turkey and Saudi Arabia). Annually data employed for 20 years from year 1996 until 2015. The findings were proven by Statistical Package for Social Sciences (SPSS) showed there were positive relationship between crude oil prices with gold price. Their finding also same with Muhammad et al. (2015) in Malaysia for a data in quarterly period from year 2005 to year 2014.

Therefore, this research will continue for a gold price data in Malaysia from year 2013 to 2018. The latest factors need to be assessed in accordance with the current economic situation. This research is necessary to be carried out in order to help the gold traders successfully planning their business. It is more advantageously if the main factor of the gold price can be determined. For this reason, Fuzzy Analytic Hierarchy Process (FAHP) was introduced as an approach to evaluate, compare and rank the factors. More exciting to extend this research because there were no studies that ranking factors using FAHP.

FAHP is a method which is often used in multi-criteria decision making and to solve hierarchical fuzzy problems (Fatemah et al., 2019; Ozdagoglu, 2007; Kabir & Hasin, 2011; Cebi & Caral, 2017; Erkan & Can, 2014). This method is easy to understand and to handle with the existence of multi-criteria (Mahmoodzadeh et al., 2007). Fuzzy AHP can be used in many applications especially in solving problems involving the best selection and ranking of product or services. Based on these advantages, this research will used FAHP to rank the factors of gold price fluctuation.

The rest of this paper is organized as follows. The second section introduces the background of Fuzzy Analytic Hierarchy Process. Then, the third section explains on the data and methodology, consisting of six essential steps. In the fourth section, the findings and analysis is discussed. Finally, the fifth section presents the conclusions and future works.

FUZZY ANALYTIC HIERARCHY PROCESS (FAHP)

Fuzzy Analytic Hierarchy Process (FAHP) is one of the decision-making tools which is widely used in various multi-criteria decision-making problems. This model takes the pair-wise comparisons of different alternatives to various criteria and then provides a decision for multi-criteria decision-making problems

(Ayhan, 2013). This tool is a problem-solving method which is combination of AHP approach that use of fuzzy logic and linguistic variables (Erkan & Can, 2014).

FAHP is also widely used in business and economics. Mahmoodzadeh et al. (2007) have been applied FAHP in selecting the best project by comparing the four criteria which were net present value, rate of return, benefit cost analysis and payback period. However, this study showed that FAHP method can make the comparison of qualitative judgement to be more intuitionistic and eliminate assessment bias in pairwise comparison process. This method determines the decision criteria, obtaining the weight and selecting the best factors (Srichetta & Thurachon, 2012). This decision-making approach seems to be more accurately (Kabir & Hasin, 2011). From the previous study, it may be concluded that FAHP has proven reliable and useful in investigation of knowledge-based business plans (Fatemah et al., 2019).

METHODOLOGY

The primary data on the factors of volatility of gold price have been collected by interviewing the owner of gold traders in Arau, Perlis. The factors or criteria that were selected in this research are currency exchange, inflation, demand and mining. The experts will compare each of the criterions. By using FAHP, the most important factors that affect the changes in price of gold will be determined.

There are six essential steps in conducting the FAHP as listed below.

Step 1: Determine the criteria and the experts compare each of the criteria via linguistic term as shown in the Table 1.

Table 1: Linguistic Terms and the Corresponding Fuzzy Numbers

Scale	Linguistic Term	Fuzzy Triangular Scale
1	Equally Important (E. Imp.)	(1,1,1)
3	Weakly Important (W. Imp.)	(2,3,4)
5	Fairly Important (F. Imp.)	(4,5,6)
7	Strongly Important (S. Imp.)	(6,7,8)
9	Absolutelly Important (A. Imp.)	(9,9,9)
2 **4** **6** **8**	Intermittent values between 2 adjacent scales	(1,2,3) (3,4,5) (5,6,7) (7,8,9)

(Source: Ayhan, 2013)

Step 2: Construct the pair-wise comparison matrix, $\widetilde{A}^k$.

By using the corresponding fuzzy numbers as shown in Table 1, the pair-wise comparison matrix is constructed as form in equation (1). The score of each alternative relating to each criterion is specified as $\widetilde{d}_{ij}^{\,k}$ which is referred to the k[th] preferences of the expert of i[th] criterion over j[th] criterion.

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$$\tilde{A}^k = \begin{bmatrix} \tilde{d}_{11}^k & \tilde{d}_{12}^k & \dots & \tilde{d}_{1n}^k \\ \tilde{d}_{21}^k & \dots & \dots & \tilde{d}_{2n}^k \\ \dots & \dots & \dots & \dots \\ \tilde{d}_{n1}^k & \tilde{d}_{n2}^k & \dots & \tilde{d}_{nn}^k \end{bmatrix} \quad (1)$$

Step 3: Calculate the average fuzzy number of the criteria by using the formula in equation (2). Take note that the value of $\left(\tilde{d}_{ij}^k\right)$ is the averaged of experts preference and K is the number of experts.

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^{K} \tilde{d}_{ij}^k}{K}, \quad (2)$$

Then, the pair-wise comparison matrix will be updated and produce $\tilde{A}$ which is referred to the average of the preferences.

$$\tilde{A} = \begin{bmatrix} \tilde{d}_{11} & \dots & \tilde{d}_{1n} \\ \dots & \dots & \dots \\ \tilde{d}_{n1} & \dots & \tilde{d}_{nn} \end{bmatrix} \quad (3)$$

Step 4: Determine the geometric mean of fuzzy comparison, $\tilde{r}_i$ values of each criterion by using the formula in equation (4).

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{d}_{ij} \right)^{1/n} \text{ where } i = 1,2,...,n. \quad (4)$$

Step 5: Calculate the fuzzy weight for each criterion. Firstly, calculate the vector summation, $\tilde{d}_i$ of each $\tilde{r}_i$ by using equation (5). Find the (-1) power of summation vector and replace the fuzzy triangular number to make it in an increasing order.

$$\tilde{d}_i = \left(\tilde{t}_1 \oplus \tilde{t}_2 \oplus ...\tilde{t}_n\right). \quad (5)$$

Next, calculate the fuzzy weight of criterion, $\tilde{w}_i$ and multiply each $\tilde{r}_i$ with the reverse vector. The formula for $\tilde{w}_i$ is shown in equation (6).

$$\begin{aligned} \tilde{w}_i &= \tilde{r}_i \otimes \left(\tilde{r}_1 \oplus \tilde{r}_2 \oplus ...\tilde{r}_n\right)^{-1} \\ &= \left(lw_i, mw_i, uw_i\right) \end{aligned} \quad (6)$$

where,

l is equal to the lower number of increasing order of $\tilde{d}_i$,

m is equal to the median number of increasing order of $\tilde{d}_i$, and

u is equal to the upper number of increasing order of $\tilde{d}_i$.

Step 6: Defuzzify and normalize the fuzzy weight. By using centre of area defuzzification, the fuzzy weight, $\widetilde{w}_i$ need to be defuzzified since they are still fuzzy triangular numbers by applying the formula in equation (7). Then, it needs to be normalized by using equation (8).

$$M_i = \frac{lw_i + mw_i + uw_i}{3} \tag{7}$$

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \tag{8}$$

By following the six steps provided, the criterion with the highest score is suggested as the most important criteria.

Implementation of FAHP

After conducting the first two steps in the methodology, then the third step is to calculate the average fuzzy number. According to their preferences, the average of each criterion is resulted as follows:

$$\widetilde{d}_{ij} = \begin{bmatrix} & \textit{Currency} & \textit{Inflation} & \textit{Demand} & \textit{Mining} \\ \textit{Currency} & (1,1,1) & \left(\frac{15}{2},8,\frac{17}{2}\right) & \left(\frac{11}{2},\frac{13}{2},\frac{15}{2}\right) & (9,9,9) \\ \textit{Inflation} & \left(\frac{1}{8},\frac{1}{8},\frac{1}{7}\right) & (1,1,1) & \left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right) & \left(\frac{5}{2},\frac{7}{2},\frac{9}{2}\right) \\ \textit{Demand} & \left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right) & (2,3,4) & (1,1,1) & \left(\frac{5}{2},\frac{7}{2},\frac{9}{2}\right) \\ \textit{Mining} & \left(\frac{1}{9},\frac{1}{9},\frac{1}{9}\right) & \left(\frac{2}{9},\frac{2}{7},\frac{2}{5}\right) & \left(\frac{2}{9},\frac{2}{7},\frac{2}{5}\right) & (1,1,1) \end{bmatrix} \tag{9}$$

Next, the calculation of geometric mean of fuzzy comparison will be performed. The example of calculation for "Currency" criterion is presented in equation (10). Before determining the value of fuzzy weight of each criterion, the vector summation must be calculated and need to be power with -1. Hence, Table 2 shows the geometric mean of fuzzy comparison values.

$$\begin{aligned} \widetilde{r}_{Currency} &= \left[\left(1\times\frac{15}{2}\times\frac{11}{2}\times 9\right)^{\frac{1}{4}}, \left(1\times 8\times\frac{13}{2}\times 9\right)^{\frac{1}{4}}, \left(1\times\frac{17}{2}\times\frac{15}{2}\times 9\right)^{\frac{1}{4}}\right] \\ &= (4.3895, 4.6512, 4.8942) \end{aligned} \tag{10}$$

In the fifth step, the fuzzy weight of each of the criterion will be calculated. Therefore, the relative fuzzy weight for criteria "Currency" is shown as equation (11) and Table 3 shows the relative fuzzy weight for the criteria.

$$\widetilde{w}_{Currency} = (4.3895, 4.6512, 4.8942) \times (0.1362, 0.1489, 0.1635)$$

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$$= \left[(4.3895 \times 0.1362), (4.6512 \times 0.1489), (4.8942 \times 0.1635)\right]$$
$$= (0.5978, 0.6925, 0.8004) \quad (11)$$

In the sixth step, the non-fuzzy weight is defuzzified and normalized. Hence, the fuzzy weight for "Currency" criterion is defuzzified as shown below.

$$M_{Currency} = \frac{0.5978 + 0.6925 + 0.8004}{3}$$
$$= 0.6969 \quad (12)$$

Lastly, the normalized weight for "Currency" criterion is calculated as follows and the result is shown in Table 4.

$$N_{Currency} = \frac{0.6969}{0.6969 + 0.0828 + 0.1729 + 0.0586}$$
$$= 0.6892 \quad (13)$$

RESULTS

The factors for the volatility of gold price were determined and compared by the experts. The factors or criteria that were used in this study are currency exchange, inflation, demand and mining. In this stage, the weight of each criterion is determined based on the linguistic terms and their corresponding fuzzy numbers. After that, the geometric mean of fuzzy comparison values was calculated and the result is shown in Table 2. Table 3 shows the relative fuzzy weight for all criteria.

Table 2: Geometric Mean of Fuzzy Comparison Values

No	Criteria	Geometric Mean
1	Currency	(4.3895,4.6512,4.8942)
2	Inflation	(0.4587,0.5394,0.6455)
3	Demand	(0.9129,1.1429,1.3713)
4	Mining	(0.3536,0.3834,0.4317)
5	Total	(6.1146,6.7169,7.3426)
6	Reverse (power of -1)	(0.1635,0.1489,0.1362)
7	Increasing order	(0.1362,0.1489,0.1635)

Table 3: Relative Fuzzy Weights of each Criterion

No	Criteria	Fuzzy weight
1	Currency	(0.5978,0.6925,0.8004)
2	Inflation	(0.0625,0.0803,0.1056)
3	Demand	(0.1243,0.1702,0.2243)
4	Mining	(0.0482,0.0571,0.0706)

Lastly, the normalized weight for "Currency" criterion was calculated and the result is shown in Table 4.

Table 4: Defuzzify and Normalized Fuzzy Weight

No	Criteria	Defuzzified fuzzy weight, M_i	Normalized fuzzy weight, N_i
1	Currency	0.6969	0.6892
2	Inflation	0.0828	0.0819
3	Demand	0.1729	0.1710
4	Mining	0.0586	0.0580
5	Total	1.0112	1.0000

The value of geometric mean, fuzzy weights, non-fuzzy weights, normalized weight and ranking for all factors are presented in the Table 5. This table also shows the ranking of price gold fluctuation factors based on their weight. The factor with the highest fuzzy weight value is ranked as the best alternative which is gives the strongest effect to the gold price volatility.

Table 5: Geometric mean, Fuzzy weights, Non-fuzzy weights, Normalized weights and Rank the factors

No	Criteria	r_i	w_i	M_i	N_i	Rank
1	Currency	(4.3895,4.6512,4.8942)	(0.5978,0.6925,0.8004)	0.6969	0.6892	1
2	Inflation	(0.9129,1.1429,1.3713)	(0.1243,0.1702,0.2243)	0.1729	0.1710	2
3	Demand	(0.4587,0.5394,0.6455)	(0.0625,0.0803,0.1056)	0.0828	0.0819	3
4	Mining	(0.3536,0.3834,0.4317)	(0.0482,0.0571,0.0706)	0.0586	0.0580	4

Based on Table 5, the criteria "Currency" indicates the highest value of normalized weight (0.6892) compared to the other criteria. Therefore, the "Currency" criteria contributed as the main factor for volatility of gold price. This shows that currency exchange has more effect on the increase and decrease in the price of gold rather than other criteria. The ranking is followed by criteria of "Demand","Inflation" and "Mining" activities which also affect the price change.

There are some research explores the relationship between gold prices and currency exchange, inflation rates, demand, exchange rates and crude oil prices (Anis et al., 2019; Zakaria et al., 2015; Nair et al., 2015; Omag, 2012). Their study proved that the exchange rates, interest rates and inflation rates had a significant relationship with the prices of gold. Hence, this research finding has been improved by providing a ranking for the relevant factors. This study also determined the main factor which is currency exchange has been contributed to the fluctuation of gold price.

CONCLUSION

In conclusion, the research objectives have been fulfilled. The finding confirms that the FAHP method is suitable to be used in ranking the factor of gold price fluctuation. The results show that the main factor that contributes to the fluctuation of gold price in Malaysia is currency exchange. This outcome is expected to help the gold traders successfully planning their business.

This study can be improved by adding other alternatives to be ranked by considering its external factors as well. Besides, the future research should be focusing on other methods such as Fuzzy hybrid AHP-Topsis, Fuzzy Electre and Fuzzy Hybrid Saw-Vikor.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to the Emas Seri Arau Enterprise for their time and feedback on all conducted activities.

CONFLICT OF INTERESTS DECLARATION

The authors declare no conflict of interests regarding the publication of this article.

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