Proceedings of the 3rd International Conference on Management Research and Economic Development
DOI: 10.54254/2754-1169/2025.31232

Gold Pricing Models: Dynamic Analysis Based on ECM and Supply/Demand Balance

Guo Chen

University of Manchester, Manchester, UK
elorachenguo@gmail.com

Abstract. This paper aims to discuss the dynamics of gold pricing through two key approaches: the Error Correction Model (ECM) and the Gold Supply and Demand Balance Valuation Model. These models provide insights into how short-term fluctuations and long-term trends in gold prices are shaped. The ECM is particularly helpful for analyzing non-stationary data like gold prices, while the valuation model focuses on the interaction between supply and demand across different economic conditions. By combining these methods, we can better understand the key drivers of gold prices and offer practical tools for investors, policymakers, and businesses. This study aims to bridge the gap between theoretical models and real-world market behavior, providing a comprehensive framework for understanding and forecasting gold prices in both stable and volatile markets.

Keywords: Gold Pricing, ECM, Supply and Demand, Macroeconomics

1. Introduction

The position of gold in financial markets has always been special because on the one hand it is a consumer item and on the other – an investment good. To compare gold with the conventional economic tools of investment such as equities and corporate bonds, one has to understand that the metal does not produce any revenues, dividends, or interests [1,2]. Thus, it is properly underlined that basic models of valuation are insufficient for forecasting the prices for gold, which is the major type of metal. However, it is crucial to recognize that gold is mainly considered and priced according to the basics of supply and demand dependent on specific factors of the world economy, its growth or turmoil, and monetary and credit policies of powerful central banks [3,4]. This paper seeks to discuss gold pricing through a two-pronged approach of the ECM and the Gold Supply and Demand Balance Valuation Model Quorum in light of the gold pricing model which was developed in 1983 [5].

2. Gold valuation framework

2.1. Market equilibrium methodology

The fundamental equation for market equilibrium is expressed as:

DOI: 10.54254/2754-1169/2025.31232

$$D(P^*) = S(P^*)$$

where:
• D(P *) stands for the demand function value for the equilibrium price P *.
• S(P *) is the supply function at—the equilibrium price P *.
In order to analyze gold pricing one must find out what variables can affect the demand and/or the supply, extrapolate possible demand and supply, and lastly, compute the inferred gold price level.

2.2. Demand and supply functions

Demand and supply can be expressed as linear functions of price and other macroeconomic variables:

$$dt(p) : \Delta dt = \alpha + \beta pt + \gamma Xt + \epsilon t \qquad (i)$$

where:
• d_t is the depreciation rate in year t.
• α represents a constant term which controls for the overall level of depreciation.
• p_t is the price level which is known to affect depreciation through its effect on assets' carrying value.
X_t is a vector of other variables.

$$st\,(p) : st = \alpha' + \beta' pt + \gamma t' Xt' + \epsilon'$$

where:
• s_t is the stock return for period t; p_t is the stock price for period t.
• X′is the set of observable exogenous variables for period t; (α′, β′, γ′) and ϵ′are coefficients and error terms.
• d_t and s_t are fluctuations in demand and in supply, correspondingly.
The like variables are as follows: p_t is the log changes in price.
$X_t$andX'represent set of various macroeconomic factors (for instance, GDP and interest rates).

$$y_t = f(t, Xt, \beta) + \epsilon_t \; and \; y_t' = f(t, Xt, \beta) + \epsilon'.$$

Some of these equations can be estimated with VECM formulations, which enable the modeling of the levels and the changes simultaneously.

3. Error Correction Model (ECM)

3.1. ECM in financial analysis

It is important to understand the ECM as an important technique in time series analysis especially when the data is non-stationary [4]. Some of the financial data characteristics like gold price are non-stationary in nature and hence their mean and variance properties are not stable over a period of time [1,2]. This characteristic makes the traditional regression models less effective since they assume stationarity. Here the ECM is particularly beneficial because the model is specifically aimed

DOI: 10.54254/2754-1169/2025.31232

at analysing non-stationary data while making it possible to consider short-term variation and long-term equilibrium [3,4].

3.2. Application of ECM in gold pricing

When considering gold pricing, the use of the ECM is especially useful due to its ability to conduct a rather detailed analysis of how these factors impact gold's price. Some of the factors include, but are not limited to the following: the general economic factors such as interest rates, inflation, and economic growth [3,4], the specific demand of jewelry products, demand for investment purposes, and the reserves held by the central bank [1,2].

The ECM aids in the identification not only the first round/short-run effects of these factors on the gold price but also the long-run relationships dictating gold in this long-run space [4,6].

If adjustments in the interest rate are implemented, the effects are likely to be observed in the short-run due to the fact that new changes of rates may create an impression affecting the price of gold due to the opportunity cost of possessing gold relative to other assets [7]. However, the ECM also enables carrying out further analysis as to how these short-run fluctuations tend to restore to a new long-run equilibrium whereby the parameters characterizing the behavior of Gold are near-stationary [5].

These relationships are well captured in the ECM to give insights to the investors and the policy makers. This way the ECM conveys all the necessary information about short-term fluctuations and dramatically important long-term tendencies, providing a multifaceted instrument for gold prices' understanding and forecasting [3,4]. Due to this, it is a crucial reference for anyone who seeks to mine, trade or invest in gold in some way [3].

4. Measuring the expected demand and supply

4.1. Measuring the expected demand and supply

The expected demand and supply are estimated based solely on macroeconomic variables, assuming no change in the price of gold:

dˆT (0) :While, the corresponding dynamic model is represented by:

sˆ$_T$ (0) :The estimates of dynamics are as follows:sˆ$_T$

These equations enable us to predict the fluctuations of demand and supply at a certain time, T , while leaving the effect of price change.

4.2. Calculating implied equilibrium price

The final step is to calculate the implied equilibrium price that would bring the market back to equilibrium:

$$\delta D\hat{}T\,(P\wedge)/\delta\; -\; \delta S\hat{}T\,(P\wedge)/\delta\; = 0$$

Where:

- $D\hat{}T\,(P\wedge)\; =\; DT\; -1(P\,)\; +\; d\hat{}T\,(P\wedge)$
- $S\hat{}T\,(P\wedge)\; =\; ST\; -1(P\,)\; +\; s\hat{}T\,(P\wedge)$

Given that the IMP estimate is used, then substituting it into (9), we have:

DOI: 10.54254/2754-1169/2025.31232

$$P\hat{}T = P_T - 1 + p\hat{}_T$$

There is no closed-form solution for this equation, which is why solving this equation can be achieved using iterative numerical methods like Newton-Raphson.

4.3. Gold supply and demand balance valuation model quorum

The Gold Supply and Demand Balance Valuation Model Quorum extends the assessment by dividing the supply and demand into categories. Such segmentation provides a basis for the analysis of specific factors determining the gold prices.

4.4. Segmenting demand and supply

Demand and supply are segmented into different sectors to capture the impact of diverse market participants:

$$di,t = \alpha i + \beta ipi,t + \gamma iXi,t + \epsilon i,t$$

where $d_{i,t}$ is the disease incidence rate per capita at the district level i at time t; $p_{i,t}$ is the population density per square kilometer at the i^{th} district at t.

$$sj,t = \alpha' + \beta' pj,t + \gamma' X' + \epsilon'$$

where, for i = 1, . . . , m and j = 1, . . . , m′, i and j will denote every sector of demand and supply necessary for the problem.

The overall market equilibrium then becomes:

$$X_{D\hat{}i,T\,(P\wedge)_{i=1}-}{}^{m} = X_{S\hat{}j,T\,(P\wedge)_{i=1}=0}{}^{m}$$

5. Gold valuation framework in practice

5.1. Economic expansion and gold demand

Unlike what one may find reasonable to expect that economic growth has a negative impact on gold, historical data reveals that the global economy expansion triggers the demand for gold. This is especially apparent in nations such as India and China that presently experience sound economic growth, hence, consumers of more gold in the jewelry markets.

5.2. Investment demand and central bank policies

Gold investment demand relating to, amongst others, physical markets, exchange traded instruments as well as OTC products can put strong pressure on prices. Such kind of demand is mostly witnessed in the course of the economic and political crisis and tends to reduce as the confidence in investors'

DOI: 10.54254/2754-1169/2025.31232

boost. Buy demand is also important especially given that either economic growth or risk aversion can cause central banks to beef up their gold holdings.

5.3. Gold supply dynamics

The supply of gold is influenced by two main factors: mine and metal recovery known as the recycling sector. Although the levels of mined gold remain relatively constant, the supply of recycled gold is weighed on investors and consumers' intentions to recycle their gold stocks. Such a relationship can lead to fluctuations in the supply side which in turn have impacts on the prices.

6. Historical gold pricing model (1983)

6.1. Brief introduction

Market value was attempted to be predicted in the 1983 model which was based on pricing of gold. This model is considered as one of the pioneers in adopting macroeconomic variable, including interest and inflation rates, for evaluation of gold prices. This model may be viewed as the earlier version of the contemporary models like the ECM and Gold Supply and Demand Balance Valuation Model Quorum among others.

6.2. Model formulation

The 1983 model can be expressed as:

$$P_t = \alpha + \beta 1 \text{Interest Rate}_t + \beta 2 \text{Inflation} t + \epsilon_t$$

Where:
• P_t represents gold price at time t.
• α is an intercept term, β_1 and β_2 are regression coefficients.
• ϵ_t is the error term i.e., a random variable with zero mean and a finite variance.
This model was used in explaining the bi-directional causality between the macro-economic variables and gold prices and it paved way for the development of other models such as the ECM.

6.3. Application of ECM and gold valuation model

Under the ECM method, short-run and long-run relations between gold and macrovariables can be examined to apply the ECM on gold pricing. For instance, consider the following ECM:

$$\Delta P_t = \alpha + \beta_1(\Delta \text{Interest Rate}_t) + \beta_1(\Delta \text{Inflation}_t) + \lambda(P_t - 1 - \theta_1 \text{Interest Rate}_t - 1 - \theta 2 \text{ Inflation}_t - 1) + \epsilon_t$$

Where:
• ΔP_t is the change of the price of gold at time t.
• λ represents the speed of adjustment towards the long-term equilibrium of the variable.
• This indicates that θ_1 and θ_2 are long-term coefficients.

DOI: 10.54254/2754-1169/2025.31232

This is further supported by combining the ECM with the Gold Supply and Demand Balance Valuation Model Quorum which helps to analyse short-term movements and long-term trends in the gold price.

7. Conclusion

As is the case with any commodity, the pricing of gold is dependent on a number of factors that range from macroeconomic factors and investors' behavior, policies that are implemented by the central bank among others [1]. The orthodox models of valuation are ineffective in case of gold, since this material does not produce earnings or dividends. Therefore, it becomes very difficult to place a value on gold by purely relying on income per capita and level of development, but instead, gold value can be easily explained by supply and demand side factors that is, economic growth and uncertainty. The integration of ECM and the Gold Supply and Demand Balance Valuation Model Quorum as models help to gain a more accurate understanding of the prices of gold both for the short term and for the long term equilibrium [8-10].

This paper has further illustrated that Due to the dual nature of the gold; being an industrial product and an investment commodity, has different values which are difficult to be rolled into one. Thus, by portioning demand and supply, and including the ECM we can have more accurate and provide qualitative insight into the gold price prediction. These include such pricing models for gold which started from the historical gold pricing model dating as early as 1983 with macroeconomic variables as dominant factors in the pricing of gold. Finally, this approach can provide a full picture of the dynamics of gold prices in the international market on which decision-makers as well as investors could base their decisions.

References

[1] Baur, Dirk G., and Brian M. Lucey. Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. Financial Review, 45(2): 217–229, 2010.
[2] Ghosh, Dipak, Eric J. Levin, Peter Macmillan, and Robert E. Wright. Gold as an inflation hedge? Studies in Economics and Finance, 22(1): 1–25, 2004.
[3] Batten, Jonathan A., Cetin Ciner, and Brian M. Lucey. On the economic determi- nants of the gold–inflation relation. Resources Policy, 41: 101–108, 2014.
[4] Engle, Robert F., and Clive W. J. Granger. Co-integration and error correction: Representation, estimation, and testing. Econometrica, 55(2): 251–276, 1987.
[5] Smith, Greg. London gold prices and stock price indices in Europe and Japan. World Gold Council Research Study, 20: 1–20, 2002.
[6] Baur, Dirk G., and Thomas K. McDermott. Why is gold a safe haven? Journal of Behavioral and Experimental Finance, 10: 63–71, 2016.
[7] Narayan, Paresh Kumar, and Seema Narayan. Modeling the impact of oil prices on Vietnam's stock prices. Applied Energy, 87(10): 3561–3566, 2010.
[8] Wang, Ying, Lei Yang, and Shouyang Yin. An empirical study of the relationships between gold price, oil price, and exchange rate. International Journal of Business and Management, 5(12): 172–177, 2010.
[9] Fama, Eugene F., and Kenneth R. French. Dividend yields and expected stock returns. Journal of Financial Economics, 22(1): 3–25, 1988.
[10] Pindyck, Robert S. The present value model of rational commodity pricing. Eco- nomic Journal, 103(418): 511–530, 1993.