The price of gold in the year 2000 — a forecast

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In this article, two of the most recent efforts to forecast the price of gold are discussed and a prediction for the year 2000 is provided. The forecast is based on the hypothesis that in the long run, commodity prices follow a well-defined path, which permits only gradual and slow changes. The analysis shows that the current price of gold (1985) in terms of US dollars, coincide with the long run equilibrium price simulated by the model. The forecast for the year 2000 suggests that the expected price is US $420 per fine ounce in 1983 constant dollars.
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In hierdie artikel word twee van die mees onlangse pogings om die prys van goud te voorspel, bespreek en 'n vooruitskatting word vir die jaar 2000 gemaak. Die vooruitskatting is gebaseer op die hipotese dat die pryse van handelsware oor die langtermyn 'n goedgedefinieerde patroon volg wat slegs geleidelike veranderings toelaat. Die analise toon dat die huidige prys van goud (1985) in Amerikaanse dollar, ooreenkom met die langtermynbalans soos bereken met die model. Na beraming sal die verwagte prys van goud in die jaar 2000 $420 per fyn ons wees in 1983-konstante dollars
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Introduction

Forecasting the price of gold is an integrated part of planning for the South African economy as a whole and for the individual businesses engaged in the production and distribution of the metal. In 1982 almost half a million people were engaged in the mining of gold and gold exports formed about 46% of the total South African merchandise exports. (Department of Foreign Affairs, 1985). The preoccupation of the South African community with the forecasting of the price of gold is therefore justifiable.

In this article, two of the most recent forecasting efforts (Rolfe, 1983 and Brock, 1982) are reviewed and an attempt is made to forecast the price of gold for the year 2000. The forecast can be seen as an empirical one but it is argued that it is based on the premise that commodity prices in the long run are determined by a deviation-counteracting mechanism. This mechanism permits only gradual and slow changes over time and supports a stable relationship among the prices of different commodities.

The effect of stable relative prices among different commodities in the long run, is used to overcome the unavailability of useful historical data for the price of gold. Gold used to play a monetary role and therefore its price in terms of money is distorted for most of the last century.

The prices of petroleum and silver, closely connected in the minds of investors with the price of gold, are used as intermediate steps to forecast the price of gold. By investigating the historical relationship of the prices of these two commodities with the price of gold and by utilizing long-range forecasts for their prices, the prediction of the price of gold becomes possible.

The development of two forecasts through the relative prices of two different commodities — silver and petroleum — is used for verification and reinforcement of the prediction. A large discrepancy between the two forecasts should weaken the value of the prediction whereas a coincidental prediction should reinforce its validity.

First, the studies by the Economic Consulting Services Inc (Rolfe, 1983) and by Brock (1982), are reviewed and their results are presented. Then, the hypotheses on which the forecast is based are discussed and the forecast for the year 2000 is developed.

The 1981 forecasts

Two forecasts were attempted in 1981. The first was commissioned by the Chamber of Mines of South Africa and the second by the Anglo-American Corporation. The Chamber of Mines commissioned a Washington DC firm, the Economic

Consulting Services Inc. to undertake a study of projected developments in the world gold-market over the present decade, in August 1981.

The study investigates the economic environment in which gold is produced and consumed, the future monetary functions of gold, the trading behaviour of central banks and private investors, the structural and institutional changes in investment and industrial demand, the supply of gold from secondary sources (recycling) and finally, under various assumptions, it sets out five different forecasting scenarios, covering the period 1983 – 1990.

The forecast nominal prices of gold for 1983 and 1990 and their associated assumptions are shown in Table 1. The lowest forecast price for 1983 is US $398 and the highest US $783 per troy ounce. The forecast range for 1990 is US $398 – US $1975 per troy ounce of gold. In 1983 the actual price of gold was 30% lower than the lowest predicted price, which, in addition, was reported as the 'less likely possibility'.

Table 1 Forecasted nominal prices of gold for 1983 and 1990

Assumptions		Forecasted nominal prices in US dollars 1983	1990
World inflation	0%		
World GNP growth	0%	398,80	398,30
Real interest rates	5%		
World inflation	6%	552,05[a]	914,30[a]
World GNP growth	2%	570,26	1010,79
Real interest rates	4%	588,38[b]	1106,00[b]
World inflation	12%		
World GNP growth	4%	783,57	1975,15
Real interest rates	2%		

[a] With increasing supply
[b] With decreasing supply

The interesting point is not that the actual price was out of the forecast range only two years after the publication of the study, but that no scenario including low inflation accompanied by high growth and high real interest rates was conceived.

The second study, financed by the Anglo-American Corporation, was undertaken by Dr H. Brock, in order to provide a forecast for the period 1986 – 1988.

This study, distinguished by its approach, is a combination of a modified Delphi technique and the classical supply and demand methodology.

Interviews with central bankers, finance ministers, bullion dealers, political analysts, economists, mining executives, and fashion dealers in North America, Europe, Japan, Hong Kong, Singapore, Australia, the Middle East, and South Africa were used to obtain probabilistic data on the determinants of the future price of gold.

The demand for gold was broken down into ten different market segments (private investments, large central bank investments, industrial demand, jewellery, etc.), and six determinants of the demand were defined (interest rates, level of political tension, etc.).

The supply of gold was regarded as coming from three sources, the Republic of South Africa, the communist block, and other Western countries. The factors affecting the supply from South Africa, were assumed to be price, quantity produced, the sales policy of the South African Reserve Bank, and mining wages.

The Russian sales were assumed to be dependent on the foreign exchange requirements and the production levels. The supply from all other non-communist nations was assumed to be deterministically defined because of the long-lead times required for new discoveries to come into stream.

The predicted prices of gold for 1986 – 1988 were derived by the intersection of six aggregate demand curves and four supply curves. To each of the 24 intersections, a probability was attached which was estimated as the product of the probabilities of the supply and the demand curves.

The 24 probabilistic price equilibria and their probabilities are shown in Table 2. The probability that the price in 1986 – 1988 will be less than US $518 per ounce in 1981 constant dollars was estimated to be less than 1%. Although it is still early to judge the conclusions of this study, it seems that a doubling of the price of gold during the next two years will be a great surprise to most analysts. Evidently, the expectations of the interviewed experts in 1981 were biased towards high prices.

Apart from expectations, two other factors seem to impair the efforts to forecast the price of gold. The first is what Brock calls the caveat of 'money illusion'. People do not buy an investment that they perceive to be over-priced. The relative price of an investment to other investments is more important than its absolute value. Neither of the above-mentioned studies took the factor of money illusion into consideration.

The other difficulty is the unavailability of useful historical data as far as the behaviour of the gold price is concerned, under different environmental conditions. The price of gold was linked to the dollar for most of the last century and therefore its deflated price is proportional to the reciprocal of the deflating index and it is not indicative of the environmental conditions.

Next a methodology, which overcomes these two impairing factors, is developed and a forecast for the price of gold in the year 2000 is provided.

Table 2 Probabilistic price equilibria of gold in 1986 – 1988

Equilibrium prices in constant 1981 dollars	Probabilities
518	0,01
529	0,04
542	0,04
559	0,015
570	0,06
573	0,01
584	0,06
589	0,025
599	0,10
613	0,10
614	0,015
616	0,025
626	0,10
641	0,10
643	0,025
646	0,015
656	0,06
669	0,025
671	0,06
680	0,01
689	0,04
698	0,015
704	0,04
730	0,01

Hypotheses

The forecast provided by this article is based on two a priori hypotheses. The first is that in the long-term commodity prices follow a well-defined path which permits only gradual changes. The second hypothesis is that the price of a commodity, in terms of other commodities, is constant or changes very slowly in the long run.

Commodity prices in the long run follow a path determined by the conditions of physical availability, the institutional domain in which they are traded and the technological change relative to their production and consumption.

In the case of minerals, the most important availability characteristics determining the change in their prices are the change in the grade of ore mined and the discovery of new ores. As rich ores are exhausted poor ores have to be used and *ceteris paribus*, the cost and hence the price, has to rise. Some relief can be provided by new discoveries but in the long run, the number of new discoveries will be limited and will eventually be exhausted.

The institutional context refers to the structure of the market in which the commodity is traded, to changes in the legislation affecting the production or distribution of the commodity, and to changes in the ownership of resources. Price is expected to be higher in a monopolized market than in a competitive one. Similarly, legislation can affect the market structure of the grade or ore mined. Changes in the ownership of resources affect their prices as different owners have different needs, discount rates and perceptions, and therefore, exhibit different patterns of supply.

Technological change affects the production and consumption functions and therefore affects the supply and demand of the commodity. It can be manifested either as improvement in production and/or consumption, or some form of substitution of one input for another. A classic example of the former is the advent of large earth-moving equipment in the early part of the 19th century. Improved machinery made the strip mining of low-grade ore bodies possible, and thus affected the price of metals.

Technological change is usually fuelled and directed by price and hence tends to counterbalance increases in cost due, for example, to the exploitation of poor ores or to changes in the institutional context. When the price of a commodity rises, exploration for new ores intensifies, research for substitutes increases, and new methods of production are examined and considered.

The trade-off between technological change and the factors pushing the production cost higher is not taken to mean that real prices will be stable and will always remain at the same level. In the short-run, deviations from the long-term equilibrium path are the rule rather than the exception but in the long run the deviation-counteracting mechanism, i.e. technology versus declining ore grade, impose and permit only a gradual change in the price. Technology takes time and effort to be developed and adopted, and once in place, it is rigid. Planners are not easily convinced that a hike in the price of a commodity is a permanent event and refuse to divert resources from other projects. Even after the development of a new technique, time is required for its diffusion and adoption. Businessmen are always sceptical of new developments and accept them only when they are persuaded for their value. Once in place, however, new technologies can drive the price to the other extreme. Improvements in production technology, for example, can generate an over-supply which can drive the price lower than its historical equilibrium. Low commodity and price will start increasing again. This process, however, requires time and in the mean time the commodity would be underpriced.

The long-term price-path can be increasing or decreasing, depending on the power of the factors consisting the deviations-counteracting mechanism. Exploitation of poorer ores, for example, can be assumed to lead a priori to higher prices. Technological improvement on the production line, on the other hand, manifested as one well-defined accomplishment — a revolutionary technique — or as is usually the case, as a composite of many small accomplishments, leads to lower prices. The revolutionary technique, by definition, will arrest the increase in the price due to the use of poorer ores and will generate a decreasing price-path. As the new technique is diffused, the price falls untill the new technique is universally adopted. After that, the direction of the long-term price-path depends on the trade-off between the effects of the use of poorer ores and that of small technological accomplishments.

The second hypothesis is justified on the same grounds as the first one. The deviations-counteracting mechanism stabilizes not only the price of a commodity over time, but it also takes care to stabilize the relative price of one commodity in terms of another.

When the relative price of a commodity rises, technology intensifies in the supply and demand lines of that commodity until the improved conditions push the price back to levels that are justified by the historical relation of its price with the prices of the other commodities.

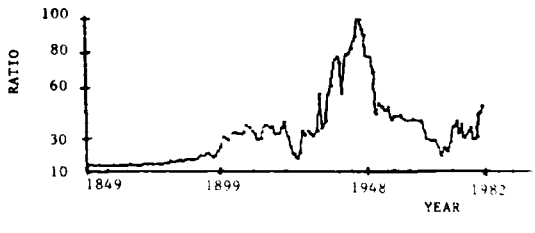
Investors believe that relative price stability should exist even in the short run and invest or speculate in the discrepancies that exist in the market. The ratios of prices of the precious metals — gold-silver, and gold-platinum — are the most often used media for this sort of investment. It is believed, for example, that the price of platinum should be above the price of gold and when the price of gold is higher than that of platinum, investors buy platinum and sell an equal amount of gold.

Based on the above hypotheses, the problems of unavailability of historical data, as far as the behaviour of the price of gold under different economic conditions is concerned, can be bypassed and a forecast of the price of gold for the year 2000 can be developed.

The forecast

The forecast of the price of gold in the year 2000 is a second-order forecast in the sense that it is based on the forecast of the price of another commodity and on a stable relationship between the price of gold and the price of the reference commodity.

Silver and petroleum are chosen as the reference commodities. Silver is one of the precious metals used for investment and industrial purposes similar to those of gold. Petroleum, although a non-recyclable commodity, is also closely linked to gold in the minds of investors, probably because of the interest taken in the metal by the Middle East investors.



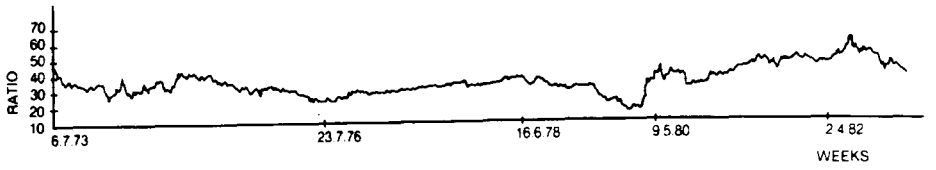


Figure 2 Ratio of the week-end fixings of gold and silver

Investors believe that an ounce of gold should be worth about 30 – 35 ounces of silver or 20 barrels of petroleum.

First, the historical relative price of gold in terms of silver and petroleum is examined and then the price of gold is derived from predictions for the price of the reference commodites.

The gold/silver ratio is examined by considering two time increments, years and weeks. The ratio of the average annual price of gold to that of silver for the period 1849 – 1982 is shown in Figure 1. Over a period of 132 years the ratio has been as high as 90 during World War II, and as low as 15 in the second half of the 19th century. The average value of the ratio over this 132-year period is 33.

Relative prices during this interval were distorted by bimetallism, wars, and economic depressions, but the average price seems to be within the investors' expectations.

In Figure 2, the ratios of the weekend fixings of gold and silver for 500 weeks, from 1973 to 1982 are plotted. The ratio had a high of approximately 61 and a low of approximately 18. The 500 weeks' average is 35,8. During that period the ratio was distorted by excessive speculation. Again, however, the average figure is in the expected area.

In sum, short-term and long-term time-series indicate that a reference level for the ratio gold/silver is between 33 and 36. The ratio exhibits a high variability but eventually it returns to the reference level.

Petroleum is the other commodity whose price is usually linked with the price of gold. In Table 3, the average price of gold, the price of the barrel of petroleum and their ratios are shown for the period 1963 – 1983. The ratio has been as high as 36 and as low as 10,84, its average value being 21,87.

Table 3 Average prices of gold and petroleum, and their ratios

Year	Gold $/ounce	Petroleum $/barrel	Gold/petroleum ratio
1963	35,09	1,40	25,06
1964	35,00	1,33	26,03
1965	35,00	1,33	26,31
1966	35,00	1,33	26,03
1967	35,00	1,33	26,31
1968	38,63	1,30	29,71
1969	41,09	1,28	32,10
1970	35,94	1,30	27,64
1971	40,81	1,65	24,73
1972	58,16	1,90	30,61
1973	97,33	2,70	36,04
1974	159,25	9,76	16,31
1975	161,03	10,72	15,02
1976	124,82	11,51	10,84
1977	147,72	12,40	11,91
1978	193,24	12,70	15,21
1979	306,67	17,26	17,76
1980	607,87	28,67	21,20
1981	459,75	32,50	14,41
1982	375,80	33,47	11,22
1983	422,47	29,31	14,41

The next requirement is a long-term forecast for silver and petroleum. Slade (1982), in an effort to reconcile the theoretical predictions of increasing prices of non-renewable commodities over time with the empirical findings of falling real prices, developed a model for the long run price movement of the non-renewable natural resource commodities. This article exploits some of the findings for prediction purposes.

The model incorporates exogenous technical changes and endogenous change in the grade of ores mined and suggests a U-shaped time-path for prices.

The model, although it suggests a U-shaped time-path for the prices, did not specify a specific functional form and therefore a quadratic function was assumed. For comparison a linear function was fitted as well. Twelve commodities were tested for empirical support of the model, among them silver and petroleum.

Annual data from the period 1870 – 1978 were fitted to the two functions and the quadratic function gave statistically significant results.

The quadratic function was of the form:

$$P_{it} = b_{0i} + b_{1i}t + b_{2i}t^2 + U_{it}$$

where P_{it} is the deflated, in 1967 constant dollars, price of commodity i at time t; t is the time measured in years (1800 = 0); and U_{it} is a random error term to allow for short run fluctuations about the long run trend.

In Table 4 the trend coefficients for silver and petroleum are shown. Under the corresponding coefficients t statistics of the estimated coefficients are shown in parentheses.

The coefficients for silver are significant at the 99% confidence level and for petroleum at the 95% confidence level. The fitted curves and the deflated prices are also shown in Figures 3 and 4.

Using the specified quadratic function and the coefficients from Table 4, forecasts for the price of silver and petroleum for the year 2000 are possible. For comparison, the forecasts for 1984 are also provided.

Setting in the quadratic function the appropriate values of t ($t = 200$ for the year 2000 and $t = 184$ for 1984), the forecast prices of silver in 1967 constant dollars are 412 c/ounce for the year 2000 and 2,70 c/ounce for 1984. In 1983 constant dollars the prices are US $12,27 per ounce and US $8,04 per ounce for the year 2000 and 1984 respectively.

Similarly, the price of a barrel of petroleum in 1967 constant dollars is US $6,4 per barrel for the year 2000 and US

Table 4 Fitted quadratic trends

Commodity	b_0	b_1	b_2	R^2	F	P_1
Silver	1692	−23[a]	0,083[a]	0,96	1157	0,82
		(−7,6)	(7,1)			
Petroleum	10	−0,12[b]	0,00051[b]	0,60	78	0,68
		(−1,7)	(1,8)			

[a] Denotes significance at the 99% confidence level
[b] Denotes significance at the 95% confidence level
P_1 autocorrelation coefficient of the error term

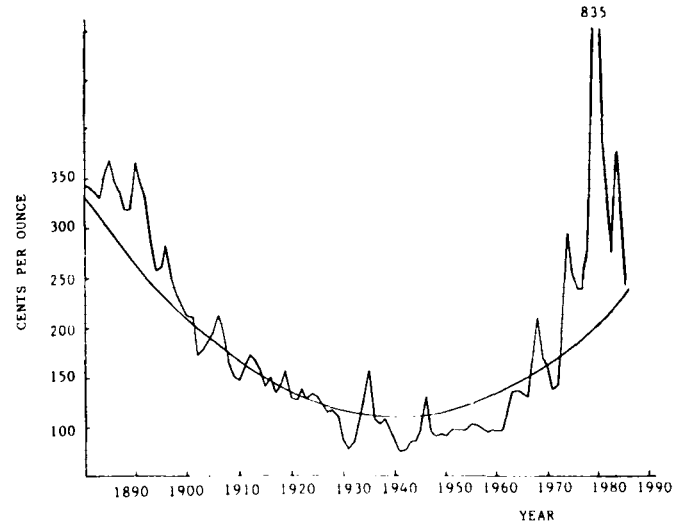


Figure 3 Deflated prices of silver and trend

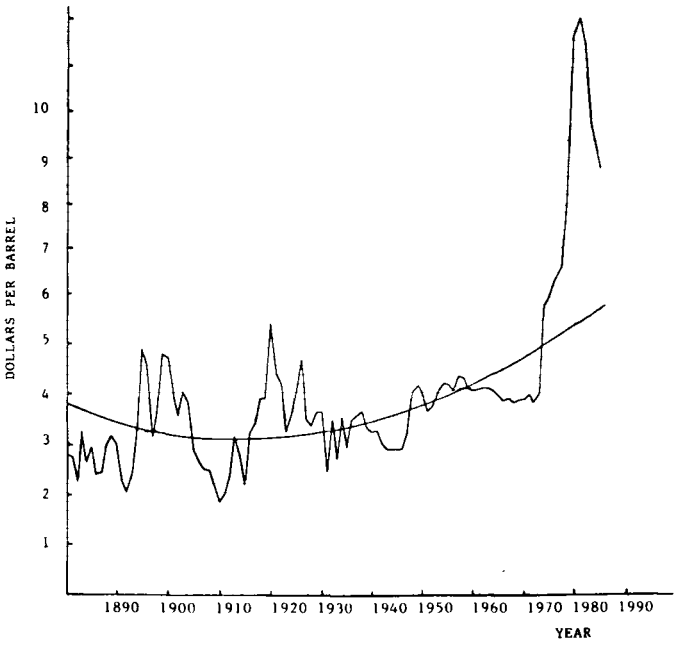


Figure 4 Deflated prices of petroleum and trend

$5,18 per barrel for the year 1984. In 1983 constant dollars, the prices are US $19,07 per barrel and US $15,46 per barrel respectively.

The forecast for the price of petroleum in the year 2000 is in accordance with the price predicted by Nordhaus (1979). Nordhaus summarized the results of 11 studies which forecast the optimal or limit prices for OPEC and concluded that the range of prices for the year 2000 is from 15 to 30 US dollars per barrel, in constant 1983 dollars.

Having the long run equilibrium prices for silver and petroleum for the years 1984 and 2000, and the historical ratios of their prices with the price of gold, the estimation of the price of gold is possible.

For the year 1984 (in constant 1983 prices), the estimated equilibrium price of gold, received through the price of petroleum, is US $338 per ounce. The prediction through the price of silver gives a range between US $265 and US $290 per ounce, depending on the assumed ratios (33 – 36).

The forecast for the year 2000 is US $417 per ounce (in 1983 constant dollars) when the price is estimated through the prediction of the price of petroleum and US $405 – US $442 per ounce when it is estimated through its relation with the price of silver.

It should be noted that the two forecasts (through silver and petroleum) of the price of gold in the year 2000 converge towards a price of approximately US $420 per ounce. The forecast through the price of petroleum falls exactly in the middle of the range indicated by the forecasts through the price of silver. This convergence is interpreted as a verification of the hypothesis advanced in this article that in the long run commodity prices are determined by a deviation-counteracting mechanism.

Conclusion

This article provides a review of the most recent efforts, financed by South African Institutions, to forecast the price of gold, and attempts to predict the long run equilibrium price of gold for the year 2000.

The forecast is based on the hypotheses that in the long run commodity prices are determined by a deviation-counteracting mechanism which permits only slow and gradual changes, and that the relative prices of the commodities are stable in the long run.

The methodology followed has the advantage that it overcomes the obstacle of unavailability of useful data on the price and the determinants of gold during the last century.

The historical price ratios gold/silver and gold/petroleum are estimated from time-series and range from 33 to 36 and from 21 to 22 respectively. Long-range forecasts for silver and petroleum are attempted utilizing studies which examine the long run equilibrium prices of these commodities. The price of gold in the year 2000 is predicted to be US $420 per ounce in 1983 prices.

For comparison, the 1984 long-run equilibrium price of gold is estimated to lie in the range of US $265 – US $338 per ounce in 1983 prices.

It seems that the price of gold, after an overshooting reaction to the US attempts to prevent market prices rising above the official prices in the 1960's has returned to within its long-run path.

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