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The Significance of Price in Determination of Zimbabwean Gold Production

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Abstract:

Zimbabwe's gold production trend over the period 1982-2015 exhibits an initial increasing trend up to 1999, followed by a generally decreasing trend. Direct observation of the price trend over the same period is not supportive of the postulated positive relationship between gold output and price. This study uses the econometric approach to test for the significance of the price variable in explaining gold production movements over the period. The study concludes that the effect of several and inconsistent policy changes over the period (both political and economic) had a preponderant effect on gold production that overshadowed the price incentive (or disincentive). There is need for a political convergence that is capable of fostering a conducive political environment in which political risks and uncertainties are significantly diluted. Government needs to revert to its past assistance and support programmes of the 1982-1999 period, examples of which include advisory support to small-scale miners, loan schemes, mobile drilling facilities, plant hire schemes, tax incentives for export market development (an export promotion scheme). The Ministry of Mines and Mining Development and related institutes, need to be better funded in order to 'feed the goose that lays the golden egg'.

Keywords: world gold prices, gold production, political risk, macroeconomic stability

1. Introduction

Zimbabwe's richness in gold is apparently a fact beyond controversy. Gold is among the several minerals that were worked before the arrival of the colonial settlers in Zimbabwe (Roussos, 1988). The initial invasion of the country by the Portuguese and later by the British is evidence of this richness (Vallieres, 1993). Zimbabwe also has one of the highest gold productivity per square kilometer in the world. As a result of this high productivity, in history Zimbabwe's production has many times been comparable to that of some of the largest world producers such as the US, Canada, Australia, and Brazil, though all fall behind South Africa.

It is generally agreed that Zimbabwe is underexplored, especially using modern methods of exploration. The over 4 000 recorded gold deposits in the country are almost all associated with ancient workings, which indicates serious paucity in purely Greenfield exploration (Ministry of Mines and Mining Development, 2011). However, this, looked at from another angle, represents a current great opportunity in the gold sector for investment in exploration and subsequent development and production.

However, one salient feature about the gold sector production trend in Zimbabwe since the 1960's has been its significant fluctuation, resulting in an irregular trend as compared to that in prices (note that the trend comparison here is not in direction, but regularity). Significant fluctuations are also observed even in the trend of the country's percentage share in world gold production (see Figure 1).

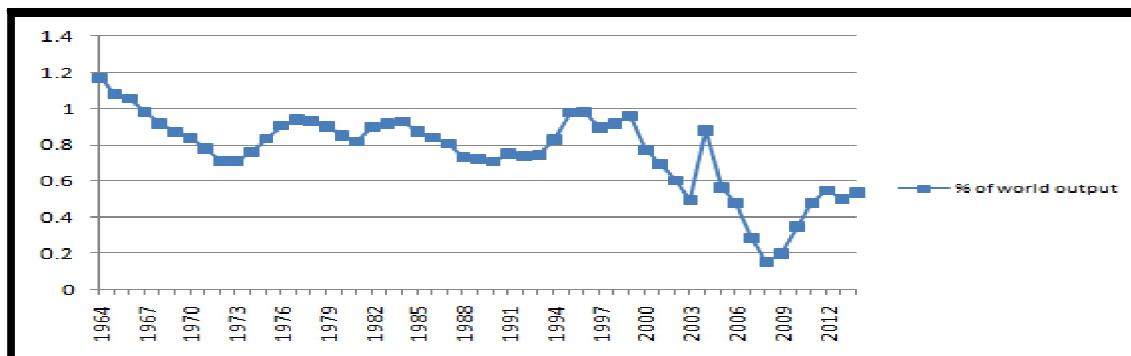


Figure 1: Trend of Zimbabwe's Percentage Share in World Gold Production (1964 - 2014)ⁱ

2. Statement of the Problem

The historical fluctuations alluded to above in the production of gold in Zimbabwe have not been fully explained. This study is concerned with the post independence production, in particular 1982 – 2015. This period is characterized by many policy changes, not only in the mining sector, but also in the rest of the country's economic sectors. These changes precipitated serious and sometimes unprecedented dynamics in the macroeconomic and political environment in the country. At the same time, any analyst would appreciate those world mineral prices, including those of gold, are normally not stable, but fluctuating from year to year. It is, therefore, not clear how relatively significant prices have been as a determinant of gold production in Zimbabwe from year to year, vis-à-vis the impact of policy changes on the miners. This is a knowledge gap that has not yet been addressed.

3. Significance of the Study

This study is significant in that, if it proves that price is not a significant factor of the fluctuations that have been observed in gold production from year to year, this would automatically imply an urgent need to get our policies and regulations in the gold sector right and consistent. This report is coming at a time the country's gold sector in particular, albeit not immune to the more than decade-long recession, has remained a critically important contributor to the country's economic sustenance.

In the event that world price trends significantly explain these local production trends, it would be incumbent upon stakeholders to investigate and implement ways to diversify gold exports from just the primary bullion to intermediate (recyclable gold) and final end-user products (gold jewellery). The latter products are less vulnerable to price fluctuations and deteriorating terms of trade. This would mean increasing the momentum on industrialization of the gold and related (upstream and downstream) sectors of the economy. This report would obviously be of interest to various stakeholders including gold miners, mining associations, the Ministry of Mines and Mining Development, the Ministry of Finance and Economic Development, the Minerals Marketing Corporation of Zimbabwe, academia working in the area of gold, the Ministry of Industry and Commerce, to mention just a few.

4. Aim of the Study

This research aims to foster discussion and policy development on improving gold production in the country through understanding the nexus between gold production trends, prices and policy changes related to the sector.

5. Objectives of the Research

The study seeks to:

- Relate graphically, and make a comparative description of, the gold production and annual world price trends over 1982-2015;
- Statistically test the null hypothesis that year-to-year variations in gold production in Zimbabwe are not significantly explained by changes in annual world prices; and
- Discuss, in the light of the results above, the possible significance of policy and regulatory factors that could have produced the observed gold production trend.

6. Literature Review

In economic theory, the relationship between price and supply (hence, to a great extent, production) of a commodity is well-established; it is positive. The higher the price the higher production is expected to be. However, when one considers a refined difference between supply and current output, one would realize that the postulated relation may not necessarily be extended to output, due to the accumulation and de-cumulation of stocks and other factors that affect current production processes.

Gocht *et al* (1988) assert that the long-term production trends of minerals are influenced by geological, technological, financial, infrastructural, and the overall legal and economic conditions. In the short-term they cited stocks and recycling among major factors. The long gestation period of mining projects means that generally, in a situation where the current mines have limited capacity (defined broadly, including geological resources) production tends to be inelastic to price changes in the short-term. Suffice to state that, conspicuous in the analysis by Gocht *et al* is the absence of the price factor itself, implying movements in prices would affect production only to the extent that these other overriding factors would allow.

Rockerbie (1999), in his study of the relationship between gold prices and production in South Africa, argues that an increase in gold price incentivizes producers to move deeper into the shafts where ore is of lower quality. The resultant amount of gold produced (whether it would fall or increase) would depend on whether or not the increase in the quantity of ore milled outweighs the decrease in average ore grade. He concludes that, for South Africa, the possibility of a perverse (that is, negative) relationship is unlikely. Selvanathan & Selvanathan (1999) also conclude a positive relationship for the Australian gold sector, albeit a relationship that exhibits a distributed-lag effect of up to 5 years, assuming the price increases by 10% and remains constant.

7. Research Methodology

The methodology applied in this paper seeks to test the hypothesis that the movements in the current prices of gold in the world market have little influence on the production levels, but rather that it is other factors related to the macroeconomic and political environments that are more important influencers. The period considered is 1982-2015. The starting point is not exactly 1980 in order to allow the mining sector to normalize from the abnormal conditions of the armed struggle which ended in 1980 with the country's independence. However, the period exhibits changes in macroeconomic and political conditions.

The postulated production model is the conventional supply function represented by equation (1),

$$Q_t = \phi_1 + \phi_2 p_t + \mu_t, \phi_2 > 0 \quad (1)$$

where:

- (i) Q_t is gold production (in ounces) in year t ,
- (ii) p_t is the annual world price of gold in US\$/oz in year t ,
- (iii) ϕ_1 reflects the influence of other omitted factors especially the political and macroeconomic fundamentals on production,
- (iv) ϕ_2 is the price coefficient of the supply function and
- (v) μ_t is the stochastic disturbance term – that is, the deviation of the actual production observation in year t from that estimated by an OLS regression of equation (1) (line trend), which assumes, among other things that the expected (mean) value of the disturbance term, $E(\mu_t) = 0$.

The following hypothesis (null) is tested against its alternative:

$$\text{Null hypothesis, } H_0: \phi_2 = 0 \quad (2.1)$$

$$\text{Alternative hypothesis, } H_1: \phi_2 \neq 0 \quad (2.2)$$

Our test statistic is given by:

$$t = \frac{\hat{\phi}_2 - \phi_2}{\text{se}(\hat{\phi}_2)} = \frac{\hat{\phi}_2}{\text{se}(\hat{\phi}_2)} \quad (3)$$

Given that the null hypothesis tested equates the true price coefficient to zero. To decide on whether or not to accept the null hypothesis that the price coefficient is insignificant (is statistically not different from zero) we shall use the rule of thumb which states that: "If the number of degrees of freedom is 20 or more and α , the level of significance, is set equal to 0.05, then the null hypothesis β_2 (in our case ϕ_2) = 0 can be rejected in favor of the alternative hypothesis...if t value (from 3)...exceeds 2 in absolute value" (Gujarati, 1988, p.113).

8. Results and Discussions

8.1. Descriptive Results

Table 1 in the appendix respectively presents local gold production and annual world price time series (1982-2015). This table plots Figures 2 and 3 below.

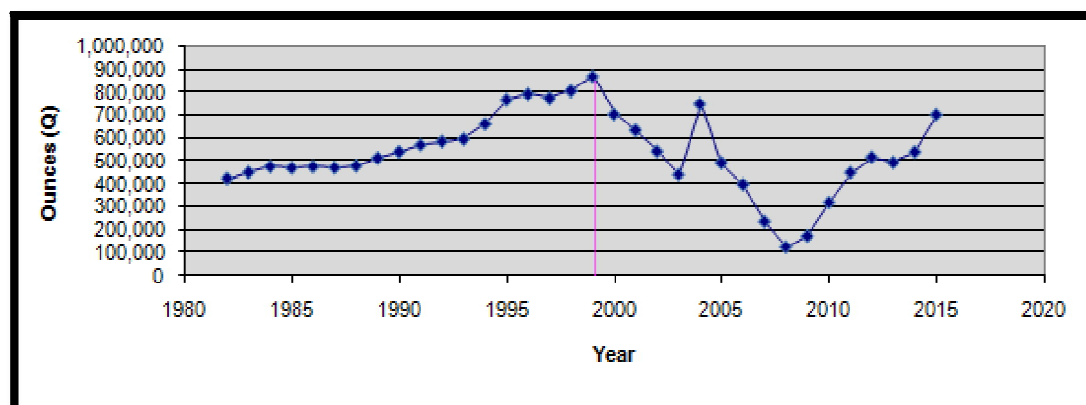


Figure 2: Gold Production Trend, 1982-2015 (Figures Used Are from Table 1)

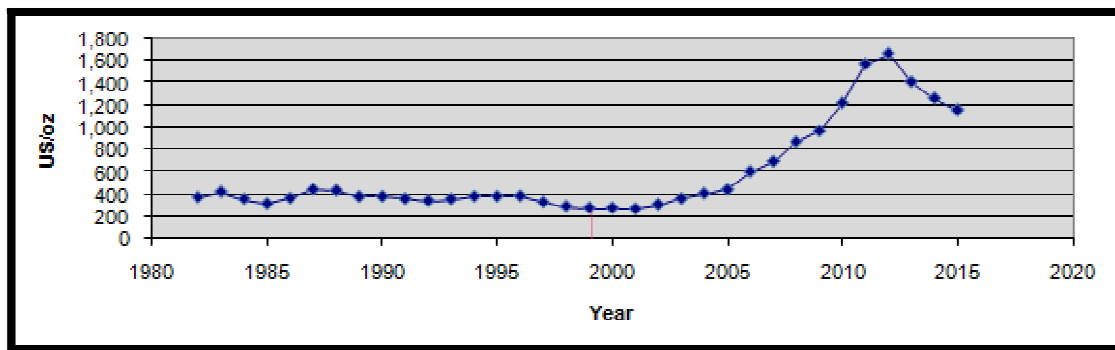


Figure 3: Gold Production Trend, 1982-2015 (Figures Used Are from Table 1)

Economic theory and common-sense postulates that when the price increases production should increase and vice-versa. However, this theory is not entirely supported and, in fact, is largely refuted by Figures 2 and 3. With the dotted pink lines demarcating the two clear periods, pertinent observations are made. During the first period (1982-1999) gold production trend is generally increasing (Figure 2) while prices remain subdued on a very slightly decreasing trend (Figure 3). From 2000 to 2008 production is generally on a decreasing trend which suddenly changes in 2009 and continues on a general increasing trend up to 2015. While from 2008 to 2012 the two graphs seem to be consistent with economic theory, the last two years again defy theoretical expectations. Thus, generally, we find that production from year to year has not mainly been driven by the current price levels.

8.2. Econometric Results

Direct application of the Ordinary Least Squares (OLS) method to data in Table 1 using LimDep 7.0 software gives the estimated regression results in equation (4). Result (4) assumes, among other things, that there is no autocorrelation – that is, disturbance terms are not related overtime.

$$\begin{aligned}
 Q_t &= 631,371 - 156p_t, r^2 = 0.13 \\
 &\quad (50,540.59)(70.53) df = 32 \\
 t &= \quad (12.49)(-2.21) F_{1,32} = 4.90
 \end{aligned} \tag{4}$$

Equation (4) 'indicates' that the quantity of gold produced in each year is negatively influenced by the price in that year – that is, when the price increases production falls and vice-versa. This result is exactly the opposite of theoretical expectations. The t value corresponding to the price variable is greater than 2 in absolute value (with degrees of freedom, df , equal to 32, hence greater than 20). This would then seem to indicate that not only does the rise in price have a negative effect on production, but that such negative effect is also significant. This is reinforced by computed F value of 4.90, which is greater than the critical F value from the F statistical distribution table which lies between 4.08 and 4.17. As much as this does not make economic sense, to some extent the descriptive analysis above seems to concur with this result.

The two indicators from equation (4) which stand out from the others, and begin to indicate the possible existence of a spurious regression (a meaningless relationship) are:

- The coefficient of determination (r^2), which stands at a paltry value of 13%, implying that the variation in the price of gold in a given year explains only 13% of the corresponding variation in production of the same year; and
- A high positive constant of more than 630,000 ounces that is not explained by the price, which constant happens to be very significant with a t -value of 12.49 benchmarked against 2.

These two points indicate that the proposed model (equation 1) leaves out the most important determinants of gold production in Zimbabwe, hence the meaninglessness of the price relationship occasioned by a specification bias.

To partially address the above problematic context, we relax the assumption that disturbances do not serially affect each other. There are several reasons why sometimes the disturbances in the various periods are related. These include, for example, the momentum built up over time in production trend (termed inertia), specification bias caused by exclusion of some important determining factors for production level (already alluded to), the existence of lagged response of output to prices, and autoregression (in which case current production is dependent on last year's production level). Thus, this study also gives estimated regression results in equation (5), corrected for autocorrelation normally associated with time-series data.

$$\begin{aligned}
 Q_t &= 535,604 + 14.63p_t \\
 &\quad (124,493.35)(137.90) \\
 t &= (4.302)(0.106)
 \end{aligned} \tag{5}$$

It is found that solving for autocorrelation makes the price coefficient assume the expected positive sign. However, the influence of price is very insignificant as reflected by a small t value of 0.106 benchmarked against 2. While the constant value falls it remains high and significant with a t value of 4.302.

8.3. Discussion

It is useful to view the above results in the contexts of the trends in economic and political developments in the country. It is very clear that the indicated trends are more significant determinants of actual gold production than the price dynamics. Accelerated production that happened between 1982 and 1999 coincided with a number of conducive economic and political factors. There was political stability, as the young country was going through a reconstruction momentum after years of armed struggle. This translated to macroeconomic stability. During this period there were also no incentives for side marketing and the country's currency was very strong and relatively stable.

The above conditions resulted in increased exploration, investment into mine development and primary production and relatively high capacity utilization levels of over 80%. This was also a period characterized by significant government assistance programs most of which were inherited from the colonial period (IMR, 1989; Roussos, 1988; Vallieres, 1993; all as cited in Mlambo, 2016a). These included advisory support to small-scale miners, loan schemes, mobile drilling facilities, plant hire schemes, tax incentives for export market development (an export promotion scheme), frequent monitoring of mining standards, *et cetera*. These were supported by strongly funded and fully operational departments of the Ministry of Mines. As Figure 3 shows, during the same period prices were generally subdued, hence the spurious negative relationship.

The period around 1997-1999 marked a turning point in not only the mining sector, but the whole economy in general. The macroeconomic environment was characterized by extreme fiscal indiscipline as exemplified by the unbudgeted-for war veterans' gratuities and the heavy expenditures related to the country's participation in the Democratic Republic of Congo war. For the first time the Zimbabwean Dollar depreciated drastically. This was followed later by serious risk perceptions and uncertainties (Mlambo, 2013) related to private property rights in the aftermath of the land reform program, which in all fairness was noble but extremely chaotic. The post 1999 era was characterized by runaway inflation (2005-2008), official exchange rate overvaluation resulting in price distortions, cash flow problems for mines due to stiff surrender requirements by the Reserve Bank of Zimbabwe (RBZ). Gold miners were forced to sell to RBZ in Zimbabwean Dollars and were paid at exchange rates that were extremely incomparable to parallel market rates where the local currency was continuously depreciating astronomically. Many gold mines went into care and maintenance while some closed shop completely.

It is notable that during the 1999-2008 era, when generally production went down the price was going up – producing the spurious relationship reflected especially in the estimations not corrected for autocorrelation. The local production peak experienced in 2004 as shown in Figure 2 was also not at all related to price movements but policy changes which happened at that time, namely: (i) deregulation of gold marketing; and (ii) improved support for small-scale miners in the form of support-prices and establishment of custom milling centres (Mlambo, 2016b).

While over the 2009-2012 period both prices and production increased, this did not necessarily reflect a positive causal relationship. This was attributed to political and macroeconomic stability that were brought about by the formation of the Government of National Unity (GNU) and the dollarization of the economy which abruptly halted the unprecedented hyperinflation rates which had gone to billions of percentages. This was followed by rehabilitation and retooling of some mines. Generally, production levels continued to increase up to 2015, though there was a price slump from 2012.

9. Conclusions and Recommendations

The study clearly indicates that over the period 1982-2015 the annual world price of gold was not a significant determinant of annual gold output in Zimbabwe. It is concluded that the effect of several and inconsistent policy changes over the period (be it political or economic) had a preponderant effect on gold production that overshadowed the price incentive (or disincentive).

The study therefore, recommends several measures: (i) political stakeholders need to find convergence and craft policies that reduce political risk and uncertainty in the country; (ii) government needs to revert to its past assistance and support programmes as enumerated under the discussion section, especially those characterizing the period 1982-1999; (iii) since gold production contributes significantly to export and fiscal revenue in the country, significant funding should be channeled to the Ministry of Mines and Mining Development and its related support institutions in order to feed the goose that lays the golden egg; and (iv) there is need, for the meantime, to maintain a reasonable level of macroeconomic stability (low inflation, exchange rate stability and fiscal discipline).

Stable inflation and exchange rates could be guaranteed by the extension and non-dilution of the dollarization regime by quasi-currencies, until all productive sectors of the economy build their capacity to maintain a local currency. This and all the above recommendations, if implemented, would positively overshadow the effect of any gold price decrease, and accentuate the significance of the positive long-term effect of gold price increase – a hope that this author glimpses from the positive, though insignificant, price coefficient in the model corrected for autocorrelation.

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Appendix

Year	Gold output, oz	Price, US/oz	Year	Gold output, oz	Price, US/oz
1982	426,000	375.67	1999	871,700	278.88
1983	453,000	424.35	2000	707,500	279.11
1984	478,000	360.48	2001	636,695	271.04
1985	472,000	317.26	2002	545,653	309.73
1986	478,000	367.66	2003	443,182	363.38
1987	473,000	446.46	2004	752,394	409.72
1988	481,000	436.94	2005	494,647	444.74
1989	515,000	381.44	2006	400,501	603.46
1990	543,000	383.51	2007	238,099	695.39
1991	572,900	362.11	2008	126,246	871.96
1992	587,700	343.82	2009	175,135	972.35
1993	597,900	359.77	2010	320,993	1,224.53
1994	664,700	384.00	2011	452,353	1,571.52
1995	770,300	384.17	2012	520,009	1,668.98
1996	794,100	387.77	2013	496,136	1,411.23
1997	776,600	330.98	2014	542,716	1,265.00
1998	809,400	294.24	2015	706,185	1,160.00

Table 1: Gold Output and Prices

Sources: ZIMSTAT/CSO; Index Mundi (2015); Chamber of Mines; Coakley J.G. (2002); Kitco Metals Inc. (2015)

¹World production figures used are from <http://minerals.usgs.gov/minerals/pubs/historical-statistics/ds140-gold.pdf>; and <http://www.statista.com/statistics/238414/global-gold-production-since-2005>. Sources for Zimbabwean production are as indicated in Table 1 in the Appendix.