Author's reply

To B. K. Martus

I discussed several points raised by Mr Martus in my reply to Professor Krige*.

Mr Martus discusses several possible interpretations of optimum South African sales, but in my paper these sales refer to the sales level that maximized the working profit of the whole South African gold-mining industry over the past eleven years. Mr Martus also seems to be under the impression that the paper deals with the future. While there may be references to the future, and some implications for the future may be obvious, the paper deals essentially with the past eleven years. The analysis was difficult enough without the introduction of further uncertainties by attempts to forecast the future.

Mr Martus is probably correct in anticipating a degree of scepticism about the model because it is difficult for many people to understand. Lack of understanding by decision-makers usually results in the *status quo* being perpetuated, often with unfortunate results. For this reason, the derivation of the optimum sales rate needs to be thoroughly examined and the findings widely publicized.

I accept, with minor reservations, Mr Martus's comments on the precautions to be taken in regression analyses. The applicability of tests for multicollinearity or heteroscedasticity in non-linear regressions with a small number of observations seems uncertain.

Mr Martus kindly gave me some papers on the direction of causality, and these show that there are still differences of opinion about the correctness of the various methods used in the application of this new concept.

To D. M. Hawkins

Before answering Dr Hawkins's criticisms, I should explain that the object of the paper is to show that actual South African gold sales exceed the optimum by a large enough margin to warrant the taking of some remedial action. Although accuracy is desirable, it is clear that this cannot be achieved with the present limited data, and the next best approach is to estimate the minimum value of this margin with tolerable accuracy.

Dr Hawkins points out that the inclusion of irrelevant variables in regressions results in serious errors in the coefficients of the relevant variables. He goes on to show that it is inevitable that this happened because of the large number of variables involved, and that the results are therefore unacceptable.

I consider Dr Hawkins's views to be too pessimistic, especially if the less accurate information mentioned above is acceptable. My reasons are given below.

There are, as has already been explained, only three regressions that significantly affect the estimated optimum sales. These regressions include only thirteen variables, with standard errors averaging 21 per cent of the

value of their coefficients. Three each are price and income variables concerned with demand. Another two are price variables concerned with the supply of scrap. It is inconceivable that any of these basic variables is irrelevant. The same can be said of the ratio of inflation to interest rates, because without this variable the regression concerned becomes meaningless.

The relevance of the remaining four variables can justifiably be questioned. However, three of them if abandoned would result in a decrease in the estimated optimum sales and must therefore be retained unless there is a good reason to discard them. The fourth variable, a ratio of the lagged price to the current price, has little effect on the optimum sales and can be ignored in this context.

Dr Hawkins is right in warning about the difficulties of detecting irrelevant variables as the following account shows. Since I submitted this paper, additional information about U.S. scrap arisings in the seventies has become available, which shows that income is not a relevant variable in the supply of scrap. It is thus almost certain that it is not relevant in the Western scrap supply in spite of a standard error that was only 22 per cent of the coefficient. The removal of this variable from the regression will result in a material lowering of the estimated optimum sales.

A comparison of the gold market with other markets is misleading. In spite of a fivefold increase in the gold price since 1970, the world supply of new gold in 1982 fell by 20 per cent and the increased scrap supply was insufficient to make up the shortfall. An approximate doubling of the price between 1931 and 1940 resulted in an increase of over 80 per cent in world mine production. Thus, a large increase in price in the thirties resulted in a large increase in supply but a drop in the seventies. The reason is simple; gold is now being mined faster than it is being discovered.

The relative rate of discovery of gold in the world excluding South Africa is somewhat better. In the thirties, a doubling of the price increased production by 2,27 times, showing a rough price elasticity of supply of 1,2. In the period from 1970 to 1982, a fivefold increase in price increased the supply by 31 per cent, showing a rough price elasticity of supply of 0,2. The latter figures exclude the Communist bloc because its production figures are now secret, but there is no reason to believe that, if they were available, they would show anything other than a severe drop in the price elasticity of supply over the past forty years. There are obviously not very large reserves of gold in the world, although discoveries will continue to be made. Furthermore, the achievement of optimum South African production would result in an increase in the price level of only about 15 per cent, which is hardly sufficient to cause a mining boom or provoke a rush to sell old jewellery.

Another important point is that additional production from mines outside South Africa, through lowering the price, renders more of South Africa's marginal ore un-

payable so that the optimum South African sales level drops. For instance, if during the period 1972 to 1982 the higher price had succeeded in raising the non-South African supply by a further 1000 t, the optimum South African sales for the period would have fallen by about 250 t, or just over 20 t per annum. This calculation was made by the modification of the main formula relating South African production with price and the calculation of a new optimum sales level.

To P. J. Niewenhuizen

Professor Niewenhuizen stresses the great changes that have taken place over the comparatively short period since gold was demonetized and the difficulties that these changes present in attempts to devise models. This is correct, but I do not think these difficulties are as great as Professor Niewenhuizen believes: the greatest difficulties stem from a lack of data, particularly in regard to scrap gold.

The effect of some of the factors mentioned by Professor Niewenhuizen are reflected by changes in the independent variables. Others were taken into account by using cost price indices and exchange rates for the countries concerned in determining composite real prices for gold. This proved to be a very worth-while improvement. I do not believe that any of the changes could have affected the elasticities used, because basic elasticities tend to be immutable. Practical elasticities, which often consist of a mix of basic elasticities, do change when the proportions of the mix change.

The futures markets could not have changed any of the variables mentioned above. They probably encouraged more people to gamble on the gold price, but the effect of this is, I believe, best measured by the net change in the amount of gold committed for sale, which is very small compared with the enormous turnover. The great turnover has the advantage of increasing the number of participants in the price-setting process, which leads to more-accurate pricing.

State interference in the free flow of gold might be expected to materially distort demand patterns, but this does not seem to have been serious. For example, the greatest demand for investment gold was in 1974, the year before gold was liberalized in the U.S.A. (see Table III), yet a great deal, if not most, of this gold was owned by Americans who bought and left the gold in other countries.

Other restrictions on the free movement of gold have to a great extent been overcome by smuggling, which is very prevalent. Smuggling invalidates demand data only when it is from one demand category used in the analysis to another; for example, from the West to the East. There is significant smuggling of this kind, which could not be taken into account. However, since the submission of the paper for publication, a way of minimizing the inaccuracy caused by smuggling has been devised. This indicates that the effect of smuggling is significant but not serious.

To B. G. Kingsman

I am very pleased that Dr Kingsman made a contribution to this discussion. Originally we planned to produce this paper together, but unforeseen circumstances prevented this. I am indebted to him for his invaluable advice on regression techniques.

General Comment

I am grateful to the contributors for some interesting and useful views and criticisms that will undoubtedly lead to better models being devised. However, I am disappointed that the main theme of the paper, that there has been excessive mining of low-grade ore, has received no direct comment. As some readers may have gained the impression that accurate models are necessary to justify any policy change, I would again draw their attention to Fig. 1. Unless one believes that the price of gold is not lowered by extra South African production, it is clear that the revenue curve in Fig. 1 must sag increasingly as production increases. Only visual inspection is then needed to show that the marginal price is less than the average price, and that the use of the average price as the criterion of payability will result in losses. For this reason alone, initial steps to curb increasing production of lower-grade ore could be taken with confidence.

Only when production is nearing the optimum level are accurate models needed. As this level is unlikely to be achieved other than by the depletion of ore reserves, very good models will never be essential but should nevertheless be derived if at all possible.

My paper dealt with the past with obvious implications for the future. However, it seems timely to comment on the estimate of future South African gold production given in the Chamber of Mines newsletter of March 1984. This shows an estimated increase of 53 t per annum by 1990 on the part of existing mines. This will, I estimate, reduce the real price of gold by about 4 per cent and result in a serious loss of profit for the industry as a whole. Furthermore, account should be taken of capital expenditure that will be wasted or spent prematurely.

The demand for gold is mainly a function of the growth rate of gold-buying countries. Inflation has also had an important effect but it is only transient. The high growth of the seventies ensured that the demand for gold placed a heavy burden on the supply. This burden was increased by a falling supply from non-Communist mines, and the result was an enormous increase in the gold price.

In the eighties, the growth rate of gold-buying countries has dropped to a low level and has seriously affected the demand for gold. To make matters worse, the supply from non-Communist mines is increasing. This briefly explains why the upward trend of the gold price has changed and it now tends to be downwards.

There is a grave risk that the growth rate in the Western World during the next few years will, as in the early eighties, be insufficient to ensure an upward trend in the gold price.

Should South Africa further increase this risk by increasing production when there is already a surfeit?