ECONOMIC GROWTH AND EXCHANGE RATE MISALIGNMENT: THE ROLE OF GOLD IN SOUTH AFRICA*

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1 Introduction

The impact of a large mining sector for South African economic growth is considered to have been ambivalent. On the one hand, in contrast with mineral economies with an *enclave*-type mining sector and a weaker infrastructural development, the dynamic export performance of minerals, particularly gold, stimulated domestic investment demand and spilled over into other sectors of the economy, and provided also a substantial base for government revenues. In this respect, mineral exports, especially gold (and diamonds limitedly to the first half of the century), have been attributed a role of *engine of growth* for the South African industrialisation process (Houtman 1986). On the other hand, particularly in view of the dominance of gold, a *one-crop economy* pattern of erratic or misled domestic policies and severe fluctuations has been hypothesised: while exports of gold and other minerals have provided a buffer against otherwise unfavourable trends in the terms of trade over the last two decades, they have also weakened the balance of payments position and the tax revenue base by exposing these aspects of the economy to the vagaries of a largely primary commodity-oriented form of export specialisation, thus also impinging upon short-term policy-making (Lombard-Stadler 1980: 60; Standish 1992).

For an open developing economy, stability in export earnings can be considered a precondition for the maintenance of sustained growth. Besides the direct growth effects of mining, as a factor contributing to such aspects as domestic investment, employment and exports, its indirect implications should also be examined. The latter include the influence of international mineral commodity prices on the local exchange rate. In several developing mineral economies, including South Africa, unstable and misaligned levels of the RER have been attributed negative effects on the tradables sector, to the extent of being found "the one single most important form of distortion affecting economic growth" in LDCs (Agarwala, quoted by Ghura-Grennes 1993: 158)[1]. Real exchange rate (RER)

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1. Ghura and Grennes (1993) find a negative influence of RER overvaluations in Africa even on imports, as an indirect effect of increased import barriers, raised as a response to a decline in export earnings.

volatility and misalignments tend to induce uncertainty in investment decisions and inefficiency in allocation of resources[2].

With reference to the South African experience in the 1980s, an econometric analysis on monthly data substantiates the above argument, relative to the gold price and exchange rate variables (Mainardi 1995). However, data constraints prevent from distinguishing between possible changes in the equilibrium RER (ERER)[3] and actual RER misalignments. Moreover, since the analysis covers a period of twelve-thirteen years, no clear indication of long-term growth implications can be inferred from that study. This task is more feasible if annual data are used, for a larger set of variables.

The following analysis considers the role of gold for the growth of the South African economy over the period 1970-1994. The analysis links micro features of gold mining, such as tax rates and ore grade, to more general macroeconomic characteristics. Among the latter, particular attention is paid to the estimation of exchange rate misalignment, and the relationships between the gold price, the real exchange rate, and growth. The choice of gold is due to its dominant role and high sensitivity to changing international conditions. Results of the model are then applied to an ex ante simulation for the second half of the 1990s.

2. While RER misalignment is a rather uncontroversial subject, the volatility of economic variables, such as government spending, has been attributed contradictory implications for growth. While several studies tend to associate this volatility with policy uncertainty, suboptimal output and unstable investment, a few contributions highlight its precautionary savings effect, which would eventually foster investment and growth. The empirical evidence appears to support the former view (Ramey-Ramey 1995). In the case of South Africa, RER volatility is not necessarily to be associated with economic volatility. While gold exports are believed to have smoothed cyclical fluctuations, gold and platinum producers are considered to have benefited from a significant degree of volatility in the exchange rate until the late 1980s, the argument being that this volatility tended to follow the course of the gold price in dollar terms. The exchange rate instability, along with factors such as trade sanctions and the skilled labour shortage, have undermined the expansion of industrial exports, despite the manufacturing export promotion pursued over the 1980s (Kahn 1992; Black 1992).

3. Equilibrium RER is usually defined as the RER which allows a simultaneous attainment of external and internal equilibrium conditions, given sustainable levels of other variables. Actual and equilibrium RER are supposed to converge only slowly if no consistent policy measures are implemented (Williamson 1994: 89). For South Africa, the real effective exchange rate (REER) provided by the SARB, used in this analysis, includes the six major trading partner countries. Value increases in this REER index imply real appreciations of the rand, and vice versa for decreases.

2 Model and Data Sources

The recursive equation model applied in this analysis embodies variables related to South African gold mining, exchange rate policy and growth. The model includes seven behavioural equations and four identities (Table I, part a). Four variables are assumed to be exogenous, i.e. the gold price in US dollars, the nominal exchange rate, domestic inflation, and the capital stock in the 'rest' of the economy (i.e. all sectors except mining and quarrying). With regard to other five variables listed in Table I, respective one-year lags are introduced as predetermined endogenous variables.

The last year of the series is associated with the recent political changes and a likely anomalous performance in some of the variables. Moreover, when these estimations were first run, statistical information for 1994 was not available for all variables included in the model. The later availability of complete updated data for 1994 has allowed to check for parameter stability over that year and suggested the insertion of dummies accounting for aspects not captured by the quantitative variables. Respecifications of the functional forms initially adopted for OLS regressions over the period 1970-1993 and dummies have been considered necessary whenever the Chow forecast test fails to reject the parameter stability hypothesis (equations [1], [4] and [8]). In equation [9], the dummy for 1980 would not be necessary according to this test, but it appears to be justified in view of the widening gap occurring in that year between profits and investment decisions. These aspects are reconsidered below, with a brief treatment of individual variables and regression equations, separately.

During the 1980s, the South African nominal exchange rate with the US dollar can be assumed to have largely depended on international gold price movements, so as to maintain minimum levels of profitability for gold exports in rand terms, as hypothesised by various studies (Kahn 1992; ADB 1995: 91). With the exogeneity condition this assumption is relaxed here. For the sake of simplicity, moreover, the interaction of inflation with macroeconomic policy variables, e.g. money supply and exchange rates, is ignored.

The average working costs per tonne of ore milled are supposed to depend on inflation (Posel 1989: 46-47) and a lagged endogenous variable. This lagged variable can assume a near-unitary coefficient. In this case, the functional form of the regression equation ([1]) would be equivalent to a lin-log function with both variables in level form (i.e. *wcos* and *1n(CPI)*). Except for 1993 and, particularly, 1994, this function actually captures well the pattern between the two variables over the period analysed, with inflation tending to be lower than annual percentage changes in average working costs of gold mining until the early 1980s, and vice versa in later years. Compared to a regression specification with both variables in differenced form, equation [1] offers the advantage of directly estimating average working costs in levels. Moreover, unlike the lin-log function, it avoids serial correlation. A dummy variable for the 1994 exceptional working cost increases has also been added.

The grade of the ore is considered endogenous: this variable can be considered as partly endogenous, since, independently from the changing geological environment (which can to some extent be traced by a lagged endogenous variable), South African mining companies tend to adjust production according to gold prices and tax purposes. The latter factors affect the payability of different grade seams once operating cost pressures are accounted for (Minerals Bureau 1990a; Handley 1990). In the regression equation which models the ore grade (equation [3]), therefore, the gold price in rands is adjusted by a deflator based on the fitted values of the average cost variable.

Given certain ore grade attainments and previous year levels of production, gold supply in terms of ore milled can be modelled (equation [4]). The volume of ore extracted can be considered a better measure of real economic activity of the sector than net gold output, in view of the reasons discussed by Moll (1992: 190-191). In connection with the jump in working costs, for 1994 a dummy is added, given the extremely high contraction in gold mining output (close to 7% in volume terms, according to provisional estimates) (Chamber of Mines 1995a: 21). This contraction leads to a lack of parameter stability if equation [4] (with no dummy) is estimated over the 1970-1993 period, as compared to regression estimates including 1994, with an overestimate of supply for 1994 and, most probably, for the following years.

Results of the first three behavioural equations can then be used to estimate average working revenue, and average and total working profits (identities [5], [6] and [7]) (Posel 1989: 44-45). Total profit, with a one year lag, is in turn entered as a regressor for estimating government taxes, thus testing the implications for tax revenues of varying levels of overall pre-tax profits in the sector (equation [8]). Even if a plot (not shown here) of the two variables over time clearly highlights this relationship, government revenues out of gold mining also depend on changing tax rules, in terms of direct or indirect imposts (e.g. gold tax formula, government land leases, and import surcharges) (Minerals Bureau 1992: 14-20). This justifies the introduction of dummies for certain years, which appear to stray away from an average pattern. Years with a relatively higher tax incidence, namely a tax income higher than 50% of previous year working profits, are identified in 1975, 1976 and 1981, while the opposite extreme cases are represented by 1993-1994, with a tax incidence lower than 15%. As in equation [4], the specification in [8] avoids an excessively optimistic picture in the *ex ante* simulation.

Capital expenditure in gold mines has been seen to follow the trend of the sector's total working profits (Minerals Bureau 1990: 11). However, in periods of higher gold profitability and higher gold ore production, large spill-overs in new investment projects by the five controlling mine houses can be expected to have occurred for the mining sector as a whole, besides, to a more limited extent, for activities in other sectors of the economy where these holdings are involved. For this reason, although the distinction is necessarily arbitrary, in equation [9] investment in mining and quarrying has been regressed on lagged values of total working profits determined by identity [6], deflated, and converted into billions of rands for the sake of consistency (the absence of such a conversion would not alter regression results in [9]). Following a comparison of alternative functional forms and a graphical inspection, a Koyck-type log-lin equation starting from the second lag has been chosen[4]. A dummy has been used to account for the 1980 peak in real working profits: these profits largely accrued to government revenues, in the form of taxation and lease payments (Chamber of Mines 1981 and 1982).

On a macro level, in view of the absence of sectoral indicators for the rate of depletion of the stock, capital formation in the mining sector can almost by definition be made dependent on gross investment in this sector and the corresponding level of fixed capital stock in the preceding year (equation [10]). Alternatively, one has tried to estimate the rate of depreciation first, as the difference between values of $\{kmin_{-1} + imin\}$ and *kmin* (Table I), and subsequently projected these estimates to 1999 with a linear trend model, so as to obtain mining capital as an identity. The latter procedure does not provide realistic results in the simulation. Finally, the productivity of capital in mining, as opposed to the rest of the economy, is estimated with a simple *two-sector/one-factor of production* function (equation [11]).

Chamber of Mines and Minerals Bureau statistics, partly computerised in the Economic Analysis Systems (EASy, Pretoria) database, were relied on for the estimations. Chamber of Mines (1994; 1995a) statistical information on ore grade, revenue, costs and profits refer to Chamber gold producers, whereas the variables for government revenues from gold mines and gold output in volume of ore treated concern the whole sector, including non-members of the Chamber. Chamber producers, however, account for at

4. The reason for preferring equation [9] for the simulation, rather than a Koyck-type double-log as applied in equation [9b] (in spite of the slightly better fit of the latter), lies in the fact that, except for 1980, there has been a tendency towards an increasing reinvestment of profits over time, especially over the last few years.

least 90% of total gold supply, and relating the total ore milled to the respective supply of members of the Chamber over the period examined provides a correlation coefficient of almost 0.99. South African Reserve Bank (SARB) data for such variables as exchange rates, gold price, the CPI, and gross domestic investment and expenditure on GDP in real terms, could also be mainly extracted from the EASy database, or otherwise compiled and elaborated from SARB (v.y.).

3. Econometric Results of the Model

Econometric results for the recursive equation model are reported in Table I (part b). Alternative specifications, in terms of both functional form and explanatory variables (such as a trend variable to account for technological and/or geological changes, or lead variables accounting for expectations), led to either analogous, or less significant results, partly due to problems of multicollinearity. Some extent of multicollinearity is still likely to affect equation [11], but this specification is to be preferred to a regression based on compound growth values, expressed in terms of logarithms of the ratios of the variables to their lagged values. The latter alternative would redress the possible pattern of autocorrelation, but it definitely worsens multicollinearity problems, due to the strong covariance in the pace of change of the capital stock variables. In a recursive model, OLS can be considered as an adequate estimation technique, since error terms can reasonably be assumed to be uncorrelated across equations. The estimated parameters assume the expected sign and are mostly statistically significant at a 98% confidence interval[5].

The long-run negative elasticity of the ore grade to the rand gold price (discounted by the trend in working costs) is found to be nearly unitary, according to results based on equation [3] in loglinear form, over the period 1970-1993. Gold output in quantity of ore milled has been tendentially increasing over the 1970s and 1980s, while an apparent reversal of this trend is observable in the early 1990s. The average ore grade has nearly mirrored these changes, with inverse trends over the whole period analysed. The turning points can be identified in 1989 and 1990, for ore grade and production respectively. As observed earlier, 1994 may be seen as an unusual year relative to these recent performances, since it shows declines in both gross gold production and ore grade (Figure

5. The t-statistics for the constant term are reported in Table I, in view of the medium-term simulation. The presence of some degree of multicollinearity in equation [11] induces a higher probability of type II error, with t-statistics being lower than they would otherwise be. The forecasting power of an econometric model is assumed to be generally unaffected by multicollinearity (Stewart 1984: 135-136).

1; output figures appear smoothed since they are given in square roots, so as to fit them in the same Table). Average nominal working profits, instead, undergo an unstable performance, with peaks in 1974, 1980, and 1986, and a late upturn occurring in 1993-1994. As suggested by the literature, total working profits of gold mines, once deflated by the CPI, do appear to be a leading indicator for investment in mining, apart from the 1980 peak. The fitted logarithmic values of the latter variable, obtained from regression equation [9] and feeding into [10], appear to model sufficiently the turning points of actual mining investment over the period (not shown for reasons of space).

Controversial opinions have been expressed with regard to a supposed asymmetric responsiveness of components of aggregate demand, particularly domestic investment, to changes in main mineral export prices and related foreign exchange earnings. Some authors attribute a relatively more disrupting effect to price downswings, which would be accompanied by increased levels of unemployment and a contraction in average capacity use; boom periods would in turn be affected by capacity constraints in supply, inflation, and greater *waste* of resources (Obidegwu-Nziramasanga 1981; Gelb 1988: 19). Others, instead, tend to believe in nearly the opposite occurrence (relatively higher responsiveness of domestic investment during price upturns) (Adams-Behrman 1982: 21). To this purpose, equation [9b] was re-estimated without the lagged endogenous variable, by alternatively or simultaneously inserting intercept and slope dummies with a two-year lag, so as to identify possible differences in responsiveness of mining investment to gold mine working profits in years with a relative decline in these profits (eventually also removing the 1980 dummy).

Once the Cochrane-Orcutt method is applied to remove residual autocorrelation in the transformed equation, the estimated parameters of these dummies, if separately considered, are found to be significant at a 75-80% confidence interval, with small negative parameter estimates. When the slope dummy parameter is used, the elasticity of investment to gold mining profits during years characterised by real profit increases is nearly 0.17 (95% confidence interval), and the slope dummy parameter estimate seems to indicate a barely 5% decrease (at an 80% confidence level) in this elasticity in periods of profit losses. These results lend only a modest support to the second of the above hypotheses, namely a reduced responsiveness in South African mining investment during price and profit slumps, so that long-term investment programmes would not be severely affected by these slumps. However, apart from its limited statistical significance, the lack of results when both dummies are inserted, coupled with the similar result obtained for the intercept dummy, suggests that downswings may rather affect *autonomous* components of mining investment, without an elasticity change (as captured by the slope dummy).

Following results for tax revenues obtained from a regression model excluding dummies, the marginal tax propensity is estimated to have been close to 0.3 on average over the whole period. If equation [8] is used, however, a clear difference in this propensity can be identified between the period 1970-1992 and the last two years of the series, with this estimate declining from 0.5 to 0.26. The latter equation has proved to yield apparently more plausible *ex ante* simulated values than an equation with no dummies. The introduction of an intercept dummy accounting for high-tax years does not improve the estimation or substantially alter the simulated values.

In equation [11], the two elasticity estimates are not statistically significantly different, according to t-tests on null hypotheses for each other values, although some degree of multicollinearity impinges upon the possibility of isolating the effects of each of the two variables. The estimates actually seem to suggest that capital formation directly attributable to mining may have had less influence on economic growth in South Africa than physical capital related to the rest of the economy as a whole. This obviously does not take into account inter-sectoral spill-over effects. Capital in both sectors has exhibited decreasing returns. In order to assess the influence of the capital account shock of the mid-1980s, a dummy assuming unit values from 1985 to 1992 (the last year of negative growth in the early 1990s) was introduced in both equations [10] and [11]. Statistically insignificant results were obtained for both regression equations.

4. Some Extensions

4.1. Exchange Rate Misalignments and Growth

The model used in this analysis treats growth as a function of a capital input in a two-sector economy, distinguishing between mining and non-mining. As expected, increases in the international gold price have tended to exercise positive effects on growth, particularly during peak years such as 1980 and 1987-1988 (although apparently not in 1983). However, if not adequately dealt with by exchange rate policies, a constraint to growth may have been indirectly brought about by sudden upswings and/or strong fluctuations in the gold price, through its impact on the RER. This aspect is difficult to assess correctly, in view of the interaction with several other variables, the presence of lagged effects, and possible bidirectional causal links. Moreover, modelling RER misalignments is subject to some arbitrariness, following alternative estimation procedures and selections of variables (Williamson 1994).

The equilibrium changes of the real effective exchange rate (REER: note 3) in South Africa have been modelled here by regressing this variable on a supposed permanent path of three major macroeconomic fundamentals. Three-year centred moving averages have been applied to the regressors, assuming that 2 or 3 years would be sufficient to distinguish permanent from transitory changes in the fundamentals. This appears justified by results of Koyck-type equations, applied to model the impact of exogenous shocks on the RER, over the sample period. These shocks, represented by the three (untransformed) regressors separately considered, are estimated to exercise half of their impact, as measured by the mean lag (Pindyck-Rubinfeld 1986: 232), within periods of nearly 1.5 up to 3 years.

Similar to other studies on ERER determination and in view of previous empirical results of studies for the South African RER (Gerson-Kahn 1988; Barr-Kahn 1995), the regressors, transformed in moving average (*ma*) form, included: the international gold price in US dollars (gpcma), the terms of trade excluding gold (totma), and net long-term capital movements in millions of rands (ltkcma). According to Edwards (1994: 84), external terms of trade and capital flows are generally the only RER fundamentals with reliable data. The gold price and net capital flows are used in 1990 constant terms, i.e. deflated by a proxy for world inflation (US GNP implicit price deflator: this is indicated by a *c* after the respective symbols). A dummy accounting for the abolition of the financial rand in the period 1983-1984 does not improve the statistical significance of the regression.

In spite of the pegged exchange rate vis-à-vis the US dollar in the first part of the period[6], the South African REER shows variations before 1979 which cannot be only attributed to changes in relative inflation differentials with major trading partners. Except for the period 1976-1978, the bilateral exchange rate with the US dollar fluctuated even before 1979. For this reason, a regression was run on the whole period, which turned to be 1971-1992 as a consequence of the moving average procedure. If the regression is applied to the period 1979-1992, the estimated parameters assume similar values, except for the statistically insignificant results for non-gold terms of trade. Dummies accounting for changes in the exchange rate arrangement, occurring in 1979 and 1983 (abstracting

6. While a fixed rate had previously been pursued with regard to the British pound, from October 1972 until June 1974 the South African currency remained substantially pegged to the US dollar. This was followed by a system of limited independent managed floating, largely anchored to the dollar, which remained operative until May 1979, when a *variable dollar-pegging* was introduced, set on a daily basis by the Reserve Bank. A further move towards a more directly market-determined rate, although still under the control of the Reserve Bank, occurred in August 1983 (Barr-Kahn 1995).

from the 1974 change: note 6), prove to be either insignificant, or to reflect elements already captured by the explanatory variables. Results are obtained by applying the Cochrane-Orcutt technique, since the DW test is inconclusive if an OLS estimation is applied. T-statistics are reported in brackets, under the estimated parameters:

$$\underset{(2.92)}{reer = 74.5} + \underset{(2.91)}{0.056\ gpcma} + \underset{(0.35)}{0.065\ totma} + \underset{(2.87)}{0.0046\ ltkcma}$$

$$R^2(adj) = 0.58 \qquad F(4,16) = 8.05$$
$$DW = 1.70$$

For the gold price and net capital flows the estimated parameters have the expected sign, and are significant at a 99% confidence interval. The terms of trade variable does not appear to influence the REER. Although empirical evidence tends to associate terms of trade improvements with RER appreciations, no a priori assumption can be made on the parameter sign in this case, depending on the strength of the income versus substitution effects[7]. If the terms of trade variable is removed from the estimation, similar results are obtained, in terms of intercept and slope parameters, goodness of fit, and estimated residuals. In this case, however, the aim of the regression is not to study REER *determinants*, but to identify RER *misalignments*, defined in terms of gaps between the actual RER and the ERER. The ERER, similar to Edwards (1988) and Elbadawi (1994), is given by the fitted values of the regression (Figure 2). These values can be interpreted as an *unobservable* component of the RER which is determined by long-term variations in its macro fundamentals, which include the terms of trade. The theoretical underpinnings to the model have therefore been given priority, rather than a strict compliance with standard econometric assumptions[8].

7. In the absence of offsetting fiscal and monetary policies and if not perceived as a temporary change, improved terms of trade can stimulate aggregate demand for tradables and non-tradables. While for the former the country can be assumed to be a *price-taker*, the latter goods and services are supposed to react relatively more via price adjustments, thus contributing to RER appreciation. Another channel of RER appreciation is represented by monetary inflation, fuelled by an accumulation of foreign reserves. These effects are generally believed and empirically found to outpace the substitution effect (Edwards 1986; Elbadawi 1994: 98; ADB 1995: 201).

8. This is symptomatic of the difficulty in modelling a *hidden* variable such as the ERER, with a trade-off between the compliance with theoretical underpinnings and avoidance of excessively parsimonious models on the one hand, and the risk of incurring into multicollinearity problems on the other.

In order to test whether gold price movements account still for exchange rate misalignments, once their likely effect on the ERER has been estimated, the simple correlation coefficient between the *transitory* component of the gold price variable (i.e. the difference between actual gold price in real terms and its moving average) and the residuals of the regression (considered as proxies for misalignments) can be indicative. Some degree of positive correlation is actually present (0.31). This may give credit to the argument that the intervention by the Reserve Bank to prevent the rand from appreciating during gold price booms has not been very effective (Barr-Kahn 1995).

Pooled cross-country time-series data have been used in some studies to regress growth, and eventually other indicators of macroeconomic performance, on measures of RER misalignment and/or instability (Edwards 1988: 45-46; Ghura-Grennes 1993). This analysis has instead been limited to simple correlation coefficients, in view of the need for caution above noticed. Following correlation results, growth slowdowns appear to have been associated relatively more with the extent of fluctuations around the ERER, as represented by the residuals in absolute value (correlation coefficient equal to -0.44), rather than by RER overvaluations exclusively (-0.16). Of the three years characterised by the poorest growth performance in the period, two years are associated with overvaluations of the RER (1983 and 1992), while 1985 has been accompanied by a substantial undervaluation. The latter misalignment reflects the strong, possibly excessive devaluation which accompanied the debt crisis shock in 1985. This result would seem to support the argument that the extent, rather than the nature (overvaluations as opposed to undervaluations), of RER misalignments have been a more relevant disrupting factor accompanying years of lower growth of the South Africa economy. However, results are highly sensitive to the removal of these three observations: the correlation coefficient becomes slightly more significant for overvaluations (-0.24), while it turns insignificant for the residuals in absolute value.

4.2. Simulation (1995-1999)

In spite of the recent perception of over-exposure to gold by various Central Banks, the international gold price is envisaged to follow a more favourable trend in the near future, compared to its performance in the late 1980s and early 1990s. Among other factors, this could be due to still modest levels of gold reserves by Asian countries (Roskill 1995: 104; various press reports, such as Booyens 1995) and positive trends in the demand for jewellery[9]. The average price of gold in 1995 was expected to be nearly 390-392 US dollars per ounce (Roskill 1995: 145; Bureau of Economic Research-BER, Stellenbosch, 1994 estimates: note 10). The BER forecasted a 2.3% average growth p.a. in this price in nominal terms between 1995 and 1999, in contrast with an almost continuous decline from the 1987 peak to 1992. According to the BER, this growth would however experience a gradual slowdown towards the end of the 1990s.

Besides the gold price, BER forecasts on other variables for the South African economy have been used as a baseline scenario[10]. Inflation is envisaged to return to 2-digit levels by 1996: while lying close to 10% in 1995, it is expected to rise to almost 14% in 1997, thereafter followed by a slowdown in 1998-1999. GDP growth is prognosticated to gradually decline from an expected 4% in 1995 (see however note 10) to 1.6% in 1998, followed by a recovery in 1999. A similar trend would be traced by domestic investment.

As for the remaining exogenous variables, the bilateral exchange rate with the US dollar has been projected over the simulation period through a linear autoregressive model of order 1. Estimates for 1995 and 1996 are very close to Nedcor forecasts[11], while the 1999 projected figure amounts to 4.96 rands per dollar, which implies a nearly 7% average annual devaluation over the period 1994-1999. Non-mining fixed capital stock has been endogenised following the same procedure as for the corresponding variable related to the mining sector, namely relying on simulated estimates for mining investment, BER forecasts of total investment, and a behavioural equation analogous to [10].

The use of the whole sample period as a base for *ex ante* simulations can be questioned, in view of structural changes occurring in the South African economy.

9. A more pessimistic view points to the negative effects of the recent benchmarking of the US monetary policy to movements in the US dollar gold price (Brickhill 1995). Increases in this price would be interpreted by monetary authorities as an indicator of inflationary pressures: interest rates would tend to increase and thus diminish gold investment demand. The implications would be a reduced scope for speculative investment in gold. More in general, gold is seen to have become less reactive to events which previously tended to induce price upswings of the metal; by contrast, increasing costs of holding gold may stimulate sales by Central Banks (*The Economist* 1993; Roskill 1995: 144).

10. Forecasts presented at the ESSA seminar at the University of Natal-Durban on 'Macroeconomic modelling and forecasting for the South African economy', 2 September 1994 (by B. Smit). Later estimations on GDP growth, unavailable at the time of this study, have revised downward the 1995 expected growth figure (from 4% to 2.4%). More recent estimates for 1995 point to a 3.3% GDP growth, a less dynamic performance of the US dollar gold price (384 USD per ounce), and slightly more moderate inflationary movements (Nedcor 1996: 8).

11. Nedcor forecasts were slightly more optimistic about the rate of depreciation of the rand (Nedcor 1995: 8). Later adjustments (Nedcor 1996: 8) are closer to the rates used for this simulation, although the actual exchange rate movements in 1996 have shown an understatement of the rate in both sets of estimates.

However, these changes do not appear to have substantially affected the parameter stability of the model, although this is not likely to hold in the future. If the regression equations are re-estimated over the period 1980-1994, the estimated coefficients look stable compared to previous results. An exception is represented by equation [4], which provides slightly higher *ex ante* simulated values than those presented here. Although a realistic assessment has been pursued through subsequent model revisions, this simulation should not be regarded as a forecasting analysis. It is rather aimed at testing the growth potential of the economy, given certain structural relationships hitherto characterising gold mining, domestic investment and growth, and the consistency of this scenario with medium-term growth targets as forecasted by the BER.

Results for two years of the simulation period are presented in Table II. Average working costs can be expected to increase at a slightly faster annual average compound rate (lying around 7%) compared to the early 1990s. However, these costs would not experience peaks such as registered in 1990 and 1994, and would remain below the inflation rate and the rate of increase of the rand gold price. From 1996 onwards, due to the levelling off in the changes of the rand gold price towards the end of the simulation period (following the expected performance of the gold price in US dollars), the margin between average cost and rand gold price growth rates would tend to shrink: the 1999 simulated rates amount to 6.4% and 7.3%, respectively.

The favourable evolution in the gold price would allow a reversal of the trends which had characterised the grade of the ore and gross gold production since the late 1980s and early 1990s, thus re-catching the previous tendencies (Figure 1). This would entail a progressive return to lower grade treatment and increased supply, which would both be at levels close to the respective 1988 figures by the end of the simulation period. As a consequence, the supply of fine gold in kilograms would fluctuate within the range of 620-635 tonnes p.a.: this contrasts with the more pessimistic outlook envisaged by some analysts, with annual fine gold supply expected to be barely over 500 tonnes in the next few years (Gooding 1996). The lower ore grades would not prevent the nominal average working revenue from increasing. In the period 1996-1999 the annual average compound growth of unit working revenues, costs and profits is simulated to amount to 7.4, 6.8 and 8.6, respectively. In real terms, therefore, in view of the expected rates of inflation, average profitability would be eroded.

Provided that the envisaged more than doubling of average nominal working profits between 1993 and 1999 is realised and if equation [8] with no dummy is relied on, in nominal terms tax collections from gold mining may rise, by the end of the 1990s, to levels comparable only with the best years of 1981 and 1986-1987. If only the period 1980-1993 is used as a base for the simulation, or, alternatively, a slope dummy as in equation [8] is introduced, more conservative estimates are obtained. The latter estimates still imply a recovery from the negative trend of the last few years in tax revenues from gold mining. This recovery would occur also in real terms, with an over 10% average increase p.a. between 1994 and 1999. Nevertheless, by 1999 gold tax revenues would still correspond to only 60% of their 1990 level in real terms.

The stagnation of gold mining profits in real terms, at levels slightly higher than their 1994 attainment, would determine a gradual slowdown in the recovery which is simulated to take place in mining investment from 1994 onwards. If BER forecasts are compared with these estimates, the mining sector would reduce its contribution to total fixed domestic investment, from a 9% share in 1994 (SARB 1995, March) to an expected 7.5% in 1999. Following a decline in the period 1992-1994, the capital stock in the mining sector would consequently level out in the second half of the decade, nearly maintaining its 1989-1990 achievements.

If results are applied to equation [11], the simulation model produces economic growth rates for the late 1990s which are substantially below the BER forecasts (Table II) and the actual 1994 and 1995 growth achievements (close to 3%), even if they reverse the negative performance of the early part of the decade. This implies that, if BER growth forecasts are to be accepted, various conditions ought to affect significantly the macroeconomic framework of the model in the late 1990s. No account has been taken here of the growth implications of higher fiscal revenues from mining, and of external resources, in terms of technology and investment flows. Furthermore, the progressive opening of the economy, with increased trade links with both industrial countries and other African countries, as well as spill-over effects between different sectors, should contribute to raise factor productivity and improve the prospects for economic recovery and growth.

5. Conclusions

This analysis has been aimed at investigating the linkages between specific features of the mineral sector, commodity export prices, exchange rate misalignments, and growth. Without diminishing its relevance as a source of foreign exchange, fiscal revenues and employment generation, gold mining has sometimes been blamed for its supposed destabilising macroeconomic and policy-related implications in South Africa. Moreover, the presence of a large mineral wealth, or, more plausibly, the inadequate use of this asset, has been regarded as an indirect constraint to the implementation of needed policy adjustments, in areas such as foreign trade or education. This problem is believed to have concerned also the level of the RER, characterised by extensive misalignments. The removal of these domestic policy constraints, which were previously aggravated by the international isolation of the country, can hopefully contribute to narrow the gap between the growth rates achievable according to the simulation model and the current growth forecasts for the next few years.

The recursive equation model has highlighted the high dependence of the South African economy on such factors as the performance of gold mining, the exchange rate policy and domestic price changes. According to the simulation results, the potential of gold mining in terms of government revenue is likely to be understated if only the most recent performance is considered, even if its contribution would definitely lag behind that of the 1980s in real terms. The government revenue from gold mines has been very unstable (Chamber of Mines 1995a: 6-7), but it presents a sharp slowdown from the mid-1980s, decreasing from 10% in 1986 to less than 1% in 1993, while some recovery has been registered in 1994, and estimates for the fiscal year 1994-1995 seem to confirm a recent upward tendency (Chamber of Mines 1995: 59). Similarly, mining and quarrying have progressively reduced their share in fixed domestic investment, passing from almost 15% in 1988 to close to 9% in 1993-1994. Simulation results point to a possible further decline of this share up to nearly 7% by the end of the 1990s.

The vulnerability of the economy to international gold market fluctuations does not seem to have had serious repercussions on investment: no clear asymmetrical responsiveness by investors to international commodity price and market upswings and downswings is evident. However, this does not deny the presence of excessively optimistic perceptions on the duration of gold price booms, which are likely to have led to lax macroeconomic policies, prior to the capital account shock of the mid-1980s. Among other aspects, these misconceived perceptions, coupled with the objective of protecting producers from profitability losses due to sudden decreases in the international gold price, have led to prolonged periods of disequilibrium in the real effective exchange rate.

Unlike some studies on RER misalignment, no attempt has been made at identifying *a priori* a benchmark year of exchange rate equilibrium, supposed to be characterised by a 'sustainable' level of external and internal macroeconomic balance. The relative equilibrium achieved in the external balance in South Africa since the mid-1980s appears to have largely been accompanied by a worsening internal balance, with restraints on imports affecting the level of domestic investment. Moreover, the level of domestic production activity has chronically been far from full employment equilibrium. Following the approach of other studies, RER misalignments have been proxied by the residuals of a regression equation which tries to identify changes in the equilibrium RER. These changes are supposed to be determined by macroeconomic fundamentals, thus implying the existence of no unique equilibrium year. The results inevitably depend on the choice of the reference period and fundamentals, and on the technique for modelling the permanent path of these fundamentals. The analysis not only supports the conclusions of previous studies on the relationship between gold price and RER in South Africa, but it also indicates an influence of the international gold price on both equilibrium and actual RER. Finally, years of particularly negative growth performance appear to have overlapped with a relatively more volatile behaviour in RER misalignments, although results do not hold if these (three) years are disregarded by the analysis.

(Figures 1 and 2)

Figure 1 - Gross gold output (Mt of ore milled, square root transformation) and ore grade (g of fine gold/t of ore milled) (1970-1994)

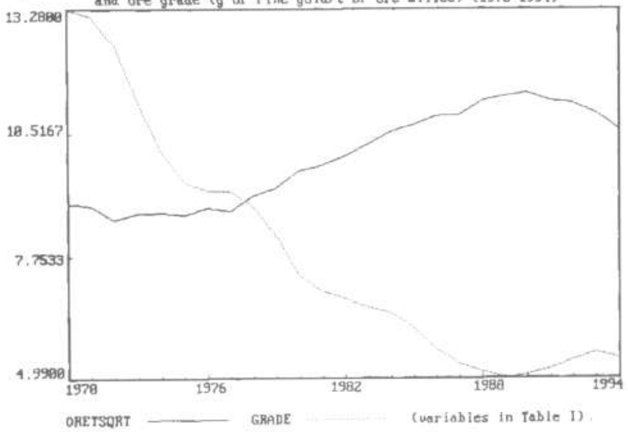

Figure 2 - Real effective exchange rate: a proxy for misalignment (1971-1992)

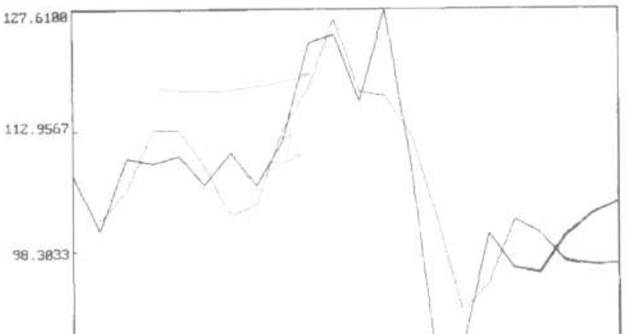

Table I: Gold Mining as a Source of Government Revenue and Growth

a - econometric model
(predetermined variables indicated in italic; expected signs of the coefficients under the variables)

wcos = f (*infl*, *wcos* $_{-1}$; dum94)	+ + +	[1]
gprand = *gpusd* • *nerusd*		[2]
grade = f (gprandco, *grade* $_{-1}$)	− +	[3]
oret = f (grade, *oret* $_{-1}$; dum94)	− + −	[4]
wrev = grade • (*gpusd*/convf) • *nerusd*		[5]
wpro = wrev - wcos		[6]
wprot = wpro • oret		[7]
tax = f (wprot $_{-1}$; wprottaxl $_{-1}$)	+ −	[8]
imin = f (wprotco $_{-2}$, *imin* $_{-1}$; dum80)	+ + +	[9] ([9b])
kmin = f (imin, *kmin* $_{-1}$)	+ +	[10]
gdp = f (*knm*, kmin)	+ +	[11]

List of variables:

convf	conversion factor (1 troy oz. = 31.1035 g)
dum80	dummy for 1980 (peak in real working profits, only partly reinvested)
dum94	dummy for 1994 (political change, with exceptional performance of gold mining, e.g. in terms of working cost increases and gross output contraction)
gdp	(expenditure on) GDP, in constant 1990 prices (R. bn.)
gprand	gold price in rands (per troy oz.)
gprandco	gold price in rands, deflated by an index based on wcos (1990 base year)
gpusd	gold price in US dollars (per troy oz.)
grade	ore grade (grams/metric tonne milled)
imin	gross domestic fixed investment in mining and quarrying, in constant 1990 prices (R. bn.)
infl	inflation rate (based on CPI, 1990 base year)
kmin	fixed capital stock (mining and quarrying), in constant 1990 prices (R. bn.)
knm	fixed capital stock (non-mining sectors), in constant 1990 prices (R. bn.)
nerusd	nominal exchange rate of the rand with the US dollar (rands per US$)
oret	total gold production in terms of ore milled (Mt treated, excluding mines doing only dump treatment)

tax	government revenue from gold mines (excluding taxes from non-mining; 31 March fiscal year end) (R. mn.)
wcos	average working costs (rands per metric tonne milled)
wpro	average working profit (rands per metric tonne milled)
wprot	total working profit (R. mn.)
wprotco	total working profit, deflated by the CPI deflator (1990 base year) (R. bn.)
wprottaxl	total working profit (slope) dummy for years with relatively lower tax incidence (1993-1994: tax < 15% wprot ,) and for simulation years (1 from 1993 onwards; 0 otherwise)
wrev	average working revenue (rands per metric tonne milled)

b - econometric results (1970-1994)

equation	constant	b_1	b_2	b_3	b_{dum}	DW Dh #	R^2 n
[1]	-3.20 (-1.34)''	0.53 (2.63)		1.05 (77.1)	10.25 (3.19)	1.08	0.99 24
[3] *	1.23 (8.96)		-0.14 (-8.41)	0.86 (59.0)		1.08	0.99 24
[4]	0.36 (3.95)		-1.86 (-3.82)	0.79 (13.6)	-9.0 (-3.0)	-0.04	0.98 24
[8] **	-1043.6 (-1.18)'		0.50 (11.8)		-0.24 (-5.3)	1.61	0.94 23
[9] *	0.58 (3.60)		0.009 (1.32)''	0.62 (5.61)	0.31 (2.22)	0.92	0.75 22
[9b] * (note 4)	0.49 (3.34)		0.12 (2.19)	0.57 (5.60)	0.30 (2.31)	0.68	0.79 22
[10] *	0.27 (6.45)		0.09 (4.78)	0.90 (69.1)		0.08	0.99 22
[11] *	2.65 (3.39)	0.34 (1.80)^^	0.16 (1.42)''			1.19***	0.96 22

#	in the presence of a lagged endogenous variable
*	all variables in natural logarithms (except for wprotco , in equation [9])
**	Cochrane-Orcutt autoregressive iterative method
***	indeterminate region (DW test)

(t statistic in bracket under the estimated parameters)

'	75% confidence interval
''	80% confidence interval
^^	90% confidence interval (in all other cases: 96% confidence interval or more)

b_i estimated regression coefficient of the exogenous variable

b_j	estimated regression coefficient of the (lagged or simultaneous) explanatory variable determined within the model
b_i	estimated regression coefficient of the lagged endogenous variable
b_{dum}	estimated regression coefficient of the (intercept/ slope) dummy variable (for equation [8] it is the coefficient associated to wprottaxl$_t$)
R^2	R^2 adjusted for degrees of freedom in multivariate models
n	number of observations

Sources: EASy computerised database; Chamber of Mines (1994; 1995a); SARB (v.y.)

Table II

Simulation Results on Endogenous Variables, Based on Forecasts and Extrapolations of Exogenous Variables for the Period 1995-1999

variable	1994 (actual)	1996	1999
wcos	172.9	196.6 (± 10.6)	239.8 (± 25.5)
gprand	1363.4	1665.5	2132.6
grade	5.40	5.34 (± 0.30)	5.17 (± 0.43)
oret	112 (provisional)	117.5 (± 8.2)	122.9 (± 10.9)
tax	818.6	1301	2499
imin	4.49	4.84 (± 2.10)	5.06 (± 2.56)
kmin	68.9	68.1 (± 4.0)	67.8 (± 6.5)
GDP growth	2.3	0.6	0.7
GDP growth (BER forecast)	2.3	3.3	3.2

95% confidence bands in brackets for OLS estimations

Sources: estimates obtained from the model in Table I, and elaborations therefrom

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Abstract

A recursive equation model is constructed to link South African gold mining to a macroeconomic framework, over the period 1970-1994. Implications are drawn in terms of real exchange rate misalignment and economic growth. The results highlight the scope for a moderate recovery in gold mining and the need for adequate development strategies, so as to use more effectively the growth potential of the mining sector and the economy as a whole.

CROISSANCE ÉCONOMIQUE ET DÉSALIGNEMENT DU TAUX DE CHANGE: LE RÔLE DE L'OR EN AFRIQUE DU SUD

Résumé

Un modèle d'équations récursives est construit avec le but de lier le secteur minier sud-africain de l'or au contexte macroéconomique, sur la période 1970-1994. On examine les implications en termes du désalignement du taux de change réel et de la croissance économique. Les résultats indiquent la possibilité d'une certaine récupération dans le secteur de l'or ainsi que le besoin de stratégies adéquates de développement, afin de mieux utiliser le potentiel de croissance du secteur minier et de l'économie dans son ensemble.