Review of Income and Wealth
Series 38, Number 2, June 1992

# ACCOUNTING FOR GOLD: THE SOUTH AFRICAN CASE

By Terence Moll

*Cambridge University*

Real output measures in the UN System of National Accounts should be continually re-evaluated, to ensure they are providing indicators appropriate for user needs. The South African gold mining industry is an intriguing case in which the conventional output indicators are highly misleading for various analytical purposes, largely because the usual background assumptions are particularly invalid. Due to the size of the industry, its precise treatment can have sizeable effects on estimates of the growth of GDP, particularly over periods when the price of gold changes. A number of easily produced additional output measures are suggested to help analyse productivity growth and differences between the growth of real output and real incomes.

## 1. Introduction

Divergences of theory and measurement in economics can be considerable, and nowhere more than in national accounting work (Eisner, 1989). As Adler observes, many attitudes and approaches of national accountants lack rigorous theoretical backing, being based on what is considered "feasible from a statistical point of view, enlightening in economic analysis, and helpful for policy purposes" (1982, p. 121). In practice, numbers are collected and ordered from thousands of different sources and sets of rules or "conventions" are developed to evaluate economic activities and allocate them to the accounting categories. The reliability of the resulting measures depends ultimately on the purposes for which the figures are to be used, particularly in the case of real output indicators (Morgenstern, 1965, pp. 95-98), but the numbers are not always interpreted in this way. Instead, there is a danger that national accountants may blindly apply sets of rules based on the experience of other countries, on a simplified reading of the United Nations national accounting guidelines, or on habit, leading to statistics being produced which are inappropriate or not helpful for many purposes.

The statistical treatment of the South African gold industry illustrates this problem clearly. The application of conventional methods of measuring real output produces consistent and easily manipulated results. Yet under closer scrutiny, it is clear that analyses of these numbers misinterpret various aspects of the growth of the industry—and of the economy as a whole—in the post-war period. The problems arise because of unusual features in gold mining, such that the usual methodological assumptions behind the accounts do not apply at all.

*Note*: I would like to thank the Human Sciences Research Council and the Leverhulme Trust for helping to fund the research on which this paper is based. Thanks also to officials in Central Statistical Service, Pretoria, for discussions and other assistance, and to Robin Matthews, John Sender and participants at a University of the Witwatersrand Economics seminar and an anonymous referee for comments.

Several easily-estimated complementary measures of real gold output and income are therefore proposed in this paper.

## 2. The Gold Industry in South Africa

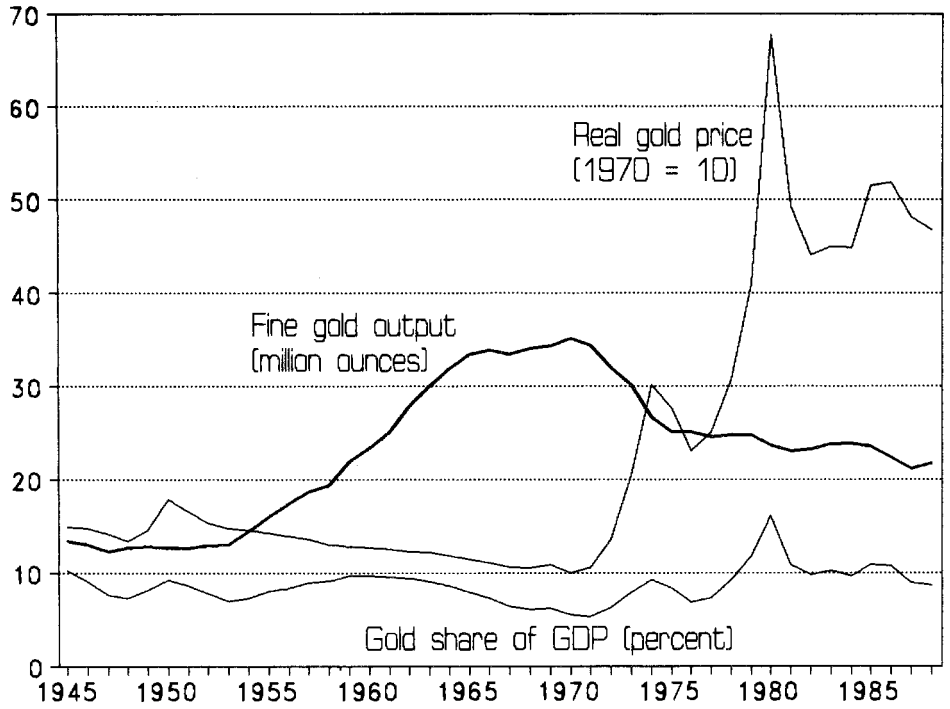
According to one observer, "For more than 100 years, the mining industry has been the very backbone of South African economic life" (Human, 1975, p. 123), with strong backward and forward linkages to the rest of the economy. Since 1945 mining receipts have averaged some 13 percent of GDP, but jumped to 22 percent when the gold price soared in 1980, while a minimum of 10 percent of the labour force has been employed in mining in the postwar period (NMC, 1989). At the heart of the mining sector is the gold industry, which earns the larger part of mining income, provides foreign exchange directly and is a hefty source of tax revenues and savings. Almost all gold output is exported, providing close to 40 percent of South Africa's export earnings since 1950 (calculated from RSA, 1988, p. 16.3). To the national accountant, gold output is a joy to deal with, being precisely measurable and homogeneous, thus virtually eliminating difficulties arising from measurement error and output quality. However, the conceptual treatment of the position of gold mining within the economy is tricky, for reasons related to the nature of the industry itself, and to the economic role of gold.

A major feature of gold mining is the unique way in which prices are determined. After 1945 the Bretton Woods agreements fixed the world gold price at U.S. $35 per ounce. The exchange rate of the South African pound (rand since 1961, at the then rate of £1 = R2) was kept at parity with sterling after the war, and the gold price of R17.25 per ounce in 1945 rose to around R25 per ounce after the 1949 devaluation of sterling and most other currencies against the U.S. dollar, where the price was to stay until March 1968. Hence, given the stable nominal exchange rate but local inflation (of around three percent per annum) and rising production costs, gold mining was subject to continually declining terms of trade against the rest of the economy, while policy-makers saw South Africa as possessing a vital national resource which was steadily becoming less privately profitable to produce. It was expected that gold production would eventually become financially non-viable—a phase usually seen as around 30 or 50 years in the future. The decline of the industry was slowed by the quality of ore mined over time being raised as the real gold price fell, by the mechanisation of some operations and by the discovery of new and cheaper sources of gold (Katzen, 1964, chapter 4).

As it happens, the world gold price rose sharply in the early 1970s, and has been erratic but consistently high in rand terms since then. The impact on the South African economy is depicted in Chart 1, which shows gold mining as share of GDP and a "real" rand gold price index, using the Consumer Price Index (CPI) as deflator. The declining share of gold until 1971 and erratic rise since, in tandem with the gold price, is particularly noteworthy. The falling rand exchange rate during the 1980s kept rand gold prices high for mining corporations, despite falls in the dollar gold price after 1980.

The most unusual feature of gold mining industry, however, is the determination of supply, which is best understood through considering a technical issue open

CHART 1. The Gold Sector and the Gold Price




*Sources*: (i) Nominal output series: Department of Statistics, 1970, pp. 5–6; RSA, 1988, p. 21.10; CSS, 1989a; (ii) fine gold output and rand gold price: Chamber of Mines of South Africa, 1990, p. 13S–14S; (iii) CPI: RSA, 1988, p. 8.21; updated using SARB *Quarterly Bulletin*, March 1990.

*Note*: The rand gold price was deflated by the consumer price index to yield the real price series. Gold output is shown in ounces, in accordance with widespread usage.

to South African gold-mine managers. At each price of gold, any mine will have a range of grades of ore available to be mined, some richer, some poorer and less profitable. The costs of processing a ton of gold-bearing ore are roughly the same across different ore-grades, and management takes the decision which of them to exploit.

Nominal gold earnings ($Y_g$) can be decomposed as follows:

$$Y_g = \text{ounces produced} \times \text{Rands/ounce}$$

$$= \text{tons gold-bearing ore milled} \times \text{ounces gold/ton} \times \text{Rands/ounce}$$

$$= \text{tons ore milled} \times \text{purity level} \times \text{Rand gold price.}$$

At a given world gold price and with infinitely elastic demand within a reasonable range, as has approximately been the case post-war, mine managers have some flexibility about where to set the purity—and hence gross profits—level in each mine.[1] The constraint is that, for dubious theoretical reasons (Franklin,

[1]While political factors sometimes intervene, this claim appears to hold in the long run. One reason is that the amount of gold coming onto the world market each year is less than one percent of known world stocks.

1954, pp. 143-144; Boyle, 1982, section 6.4), the South African state has historically maintained a policy of "maximising the working life" of the gold mines (cf. Wallace and Robertson, 1951, chapter 6) by encouraging mines to work the poorest average seams possible (termed the "pay limit") and allowing them moderate but predictable profits on their investments. Seen as benefiting the national economy in the long-term, this policy was enforced by a curious taxation system. The gold mining tax formula since the 1920s has taken the form:

$$T = \% \text{ of gold mining profits paid to government}$$
$$= a - b/x,$$

where $x$ = ratio of profits to gross revenue, expressed as a percentage, and the parameters "$a$" and "$b$" were set by the state (Storrar *et al.*, 1977, chapter 16).[2] It tends to be worthwhile for mines to push production past the stage economic theory might suggest, where marginal revenue equals marginal cost, and mine additional low-grade ore at a loss, thereby lowering the gross profit ratio and the tax burden of the mines (Boyle, 1982, chapter 6).[3] If the gold price rises, mines are encouraged to mine somewhat poorer ore on average, lowering gold output.

The effects of this system are simple. When aggregated across all mines and combined with land lease and capital allowances, the purity level—the amount of fine gold extracted per ton of ore milled—is inversely related to the real gold price (though it is also affected, of course, by various other factors). The purity level rose steadily as the real rand gold price fell in the 1950s and 1960s, from 6.4 grams of gold extracted per ton of ore milled in 1950 to a peak of 13.1 grams in 1968. Thereafter, as the real rand gold price remained high, the purity level fell by around 60 percent, to 5.2 grams of gold per ton of ore in 1988, the fall in the 1980s encouraged by the depletion of richer ores in some mines. The total gross output of fine gold rose from 13.4 million ounces (380,000kg) in 1945 to an all-time peak of around 35.3 million ounces (1,000,400 kg) in 1971, and has declined since to 21.8 million ounces (618,000 kg) in 1988 (Chamber of Mines of South Africa, 1990, p. 13S). In the long term the supply of gold moves in the opposite direction to the real gold price, as also shown in Chart 1. The South African gold mining industry thus has a negatively sloped supply curve as conventionally measured, due to government supervision.

## 3. "Real" Gold Output

### *Output of Fine Gold*

The national accounts treatment in South Africa takes these gold output numbers at face value, with curious results. When the real gold price rises, the

[2]At time of writing, for mines begun since 1966, the formula is: $T = 60 - 480/x$, allowing a minimum profit share of revenue of eight percent (Davies, 1982, p. 47). Below that, no tax is paid, and for certain marginal mines, state relief may be received. Tax surcharges have also been imposed. The tax system is being revised according to the recommendations of a 1988 investigation into mining taxation (Marais Committee), but the basic formula system will remain (Maas, 1990, pp. 15-16).

[3]The tax formula can be expressed as: Post-tax profits = $(1 - a/100) \times$ (total profits) + $(b/100) \times$ (total revenue). It will pay to mine some ore which is mildly unprofitable to produce but raises revenues enough to compensate.

industry flourishes and the gold share in nominal GDP rises, but fine gold output falls and the gold share in "real" GDP falls—a paradoxical pattern. During the 1970s, for example, investment and employment in gold mining rose sharply, but fine gold output declined at four percent per annum (see Table 1), despite the industry going through its greatest-ever boom! The gold output indicator in the national accounts is constructed using the single-deflation procedure of extrapolating base-year value-added by an index of gross physical output to yield a Laspeyres index of real output.[4] Among the implicit assumptions here are that the ratio of input to output prices and pattern of intermediate inputs remained roughly the same over the relevant time-period. These assumptions are totally inappropriate since the gold price index grew more slowly than the non-gold GDP deflator until the early 1970s, and far more rapidly since, while the changing quality of ore milled implies a different set of natural-resource inputs (see memorandum item in Table 1).

TABLE 1

TWO INDICATORS OF PHYSICAL OUTPUT GROWING IN GOLD MINING

| | Growth rates (% per annum): 1950–70 | 1970–80 | 1980–88 |
|---|---|---|---|
| Conventional fine gold output | 5.08 | −3.97 | −1.06 |
| Recalculated ore-milled index | 1.74 | 1.54 | 3.09 |

| Memorandum item | 1950 | 1970 | 1980 | 1988 |
|---|---|---|---|---|
| Grams gold retrieved per ton of ore milled | 6.41 | 12.51 | 7.21 | 5.17 |

*Source*: Chamber of Mines of South Africa, 1990, p. 13S.

The assumption that trends in input and output prices are stable can be corrected for via double-deflation—deducting inputs at constant prices from output at constant prices, as recommended by Willers and Groenwald (1963, p. 187). This procedure leads to even more odd results than the above method. Prior to 1970 it raises output growth-rates compared to the conventional approach (real output grew faster than real inputs, since richer ore was being mined), while it reduces output growth rates thereafter (real inputs grew more rapidly than real output). Over the 1967–78 period, for example, the output of fine gold fell by 2.2 percent per annum on the average, real intermediate inputs (electricity, explosives, machinery, food etc.) rose by 3.5 percent per annum, and double-deflated output fell by no less than 6.2 percent per annum (calculated from Lombard and Stadler, 1980, Tables A50–A51 and p. 43). This approach, of course, relies on the same fundamental output indicator as that above.

Nicholson (1955) argues that the interpretation of real national product assumes competitive conditions in all factor markets, such that the marginal product of each factor is proportional to its price, while only marginal changes in the aggregate basket of goods produced can be compared (pp. 146–150). Since

[4]In Hill's survey of OECD national accounting methods, this procedure was followed for mining in four countries; another six used a double-deflation procedure (1971, pp. 50–51).

such conditions can never hold perfectly, he suggests that the ultimate test of the usefulness of any index is simply "whether it stands up to the demands made on it in actual, practical problems" (p. 152). In the South African gold mining industry, the usual competitive assumptions about production and consumption cannot be said to hold even approximately. On the production side, around 30 mines, controlled by six mining finance houses coordinated in a tight web by the Chamber of Mines, produced almost all South Africa's gold in 1988 (Chamber of Mines of South Africa, 1989, pp. 4S-5S). On the consumption side, the gold price has a large speculative component and is set almost independently of production conditions and costs in the source country of almost 60 percent of gold produced in the West in the 1980s (*ibid.*, p. 16S). Most importantly, state regulation of South African gold mining means it has a negatively-sloped supply curve! At a more practical level, the fine gold output measure is clearly without value in estimating productivity growth in gold mining, or for understanding the position of gold mining within the economy. A more satisfactory approach is to consider what the "real" output concept should measure in gold mining and develop additional indicators to serve such purposes better. While various indicators are available, those which are consistent with current South African national accounting methods, which require little additional data-collection and are easily interpreted, may be preferable.

*Volume of Ore Milled*

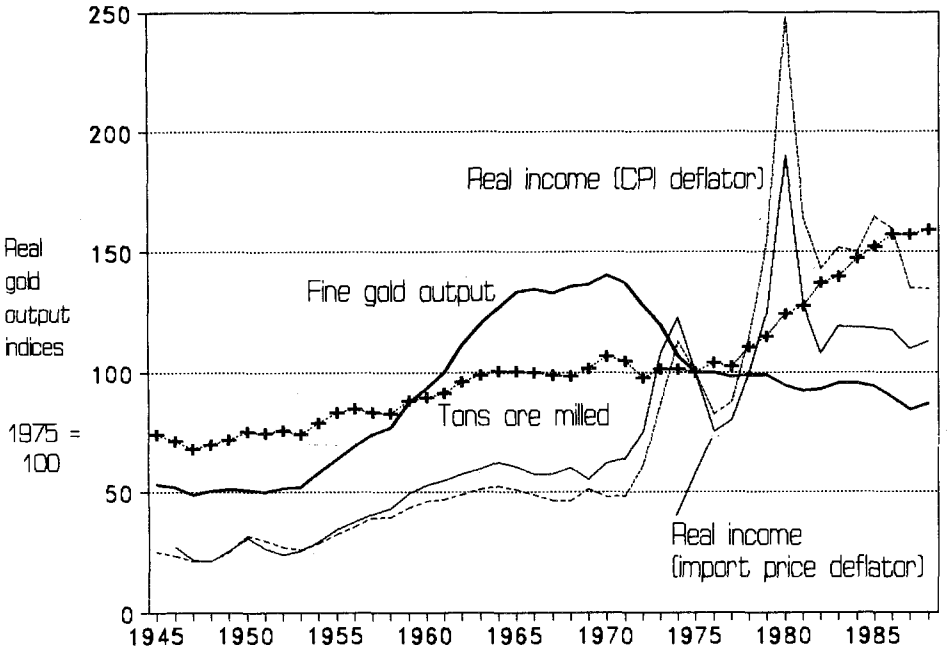
Net gold output is a poor indicator of real economic activity since it is partly a policy variable—an inverse function of the gold price. However, some crucial gold mining operations, especially stoping (the breaking and handling of rock), have remained fairly labour-intensive in the twentieth century, since most gold seams are narrow, deep and broken, often of no more than pencil thickness, thus restricting the extent to which mechansiation can take place. Accordingly, the number of tons of gold-bearing ore extracted from the ground and milled each year can serve as a fairly consistent activity-indicator of the physical work done in gold-mining, as the crushing of ore is among the central stages of producing gold (Lombard and Stadler, 1980, p. 7; Maas, 1990, pp. 8-9).[5]

The ore-milled indicator is one of those shown in Chart 2.[6] It reveals a pattern consistent with general trends in gold-mining: relative stagnation during the 1940s, steady growth after the mid-1950s when new gold fields began coming on stream, and rapid growth since the mid-1970s due to rising investment and employment levels after the gold price rose sharply. An ore-milled indicator can be used to produce a "recalculated" index of real gold output and GDP, via extrapolating base-year gold value added on the usual single-indicator basis. This

[5]It should be noted that this indicator is closely linked to the eventual diminishing-returns nature of gold mining. Over time, more accessible gold-bearing ore is used up, and lower-grade, deeper or less uniform reefs are exploited, raising costs per unit of output (Stear, 1988; Maas, 1990, p. 12). Deep-level mining, especially, has been made possible by (capital-embodied) new technology; in gold mining, technical change is required simply to maintain productivity levels, unless new seams are discovered. Measured productivity levels will be a function both of input quality and of the nature of the extraction process.

[6]Full details of all calculations and statistical series will be provided on request.

CHART 2. Four Indices of Real Gold Output (1975 = 100).




*Sources*: (i) Fine gold and ore milled: Chamber of Mines of South Africa, 1990, p. 13S; (ii) nominal gold output and CPI: as for Chart 1; (iii) import prices calculated from SARB, 1981; updated using Sarb *Quarterly Bulletins*, linked to the series at base-year 1985 after 1983.

*Note*: The real income indicators deflate nominal gold output by the CPI and import price index. The base-year for import prices is 1975.

is equivalent to assuming that the quality of ore mined—i.e. of the "intermediate" natural resource input—remains constant over time, and provides a measure of the growth of productive capacity in the gold sector.[7]

To illustrate the difference between this indicator and the conventional one, consider the estimates of growth rates of real gold sector output provided in Table 1. The periods selected are 1950-70 and 1980-88 (over which the real rand gold price was falling), and 1970-80 (real rand gold price rising). Over the 1950-70 period, the conventional indicator grew considerably faster than the recalculated one, while since 1970, as poorer ore has been mined, the recalculated indicator has grown much faster—at 3.1 percent per annum between 1980 and 1988, for example, when output of fine gold fell by 1.1 percent per annum. Productivity estimates based on these numbers would thus differ by a wide margin—e.g. by around 4.2 percent per annum during the 1980s, due to a substantial decline in the quality of ore milled, as shown in the lower panel of the table.

[7]At first sight, this indicator may seem peculiar—rather like measuring the real output of a bus company by the number of journeys undertaken rather than by the number of passengers carried (as suggested by a referee). If excess demand for bus travel prevails, however, and a regulatory authority lays down tight bus capacity limits at the beginning of each year in inverse proportion to how much passengers are willing to pay for tickets, the analogy is closer. In such a case, the number of bus journeys (a measure of potential output) may be the appropriate physical output indicator for productivity analysis.

Most analysts, however, use the paradoxical conventional results without question (Döckel and Fourie, 1978, p. 9; National Productivity Institute, 1987, Table 4). On the basis of fine gold output figures, the President's Council claimed, for the 1970–87 period, that "the mining sector registered the worst productivity performances of all the sectors shown" (1989, p. 126), with TFP apparently falling at some 4.5 per annum. Using the ore-milled indicator for gold mining, it is found that TFP falls at a far less dramatic 1.3 percent per annum (calculated from sources listed in Table 2). Following the recalculated output measure produces more credible and consistent patterns of productivity growth in the mining sector (Moll, 1990, Table 5.15 and sections 5.3 and 5.5). This indicator is regarded as appropriate for productivity measurement by some gold mining analysts in South Africa (Wagner and Boers, 1988; Maas, 1990, pp. 8–10).

*Deflated Nominal Income*

Another approach is to consider the real purchasing-power of the gold mining sector, as a measure of its importance to the national economy. Possible deflators of nominal gold earnings include an indicator of real spending-power such as the CPI, or of import prices, under the assumption that the real value of the gold production is its command over imports (Richards, 1964, p. 256; Kantor, 1988, pp. 430–432). Alternatively, the income-components of net output can be deflated separately (results differ little). Estimates of real gold buying-power using the CPI and import price deflators are also shown in Chart 2. The real income indicators grew considerably faster over the long run that the other two, and have been turbulent since 1974. The indicator based on the CPI rose at some 16 percent per annum during the 1970s decade to a once-off peak in 1980 due to the gold windfall, while the ore milled index rose at 1.5 percent per annum and gold output fell at four percent per annum over the decade. Due to import prices rising faster than domestic prices, the real income indexes have diverged in the last 10 years.

Kantor (1988, pp. 431–432) and Meth (1983, pp. 9–10) use deflated income indicators to show that real domestic income rose more than conventional GDP during the 1970s. Both authors add deflated-income figures for gold to non-gold GDP to produce a new "real" total, a curious procedure which sums figures calculated in different ways and measuring different things. This gold figure measures the effects of terms of trade changes on real incomes earned and should not be used for productivity or GDP growth claims (as done by Meth and Kantor, respectively). If a real income approach is needed for the whole economy, another method is to deflate nominal GDP as a whole by an overall price index, as done later.

*The Terms of Trade and Real Income*

Before 1970 South Africa's terms of trade slowly deteriorated, due partly to the falling real price of gold. Since then, the long-term trend has been level (improving gold terms of trade, deteriorating non-gold terms of trade), with gold-induced peaks in 1974 and 1980 (Kahn, 1991, pp. 61–62). Instead of focusing on real sectoral income as above, it is useful to develop a measure of the difference

between real output and real income in the economy as a whole, due to changes in the terms of trade. Windfall gains when the terms of trade improve (or what may be termed hailstorm losses when they deteriorate) may imply rises (or falls) in consumption, personal income, investment or government spending not justified by simple changes in overall productivity. A real income measure can thus be useful in analysing real output and expenditure trends and in evaluating incomes policies. Likewise, windfalls present policy problems: are they permanent or temporary? How should they be used, and over what time-periods? A measure of the magnitudes concerned can provide a useful input into economic policy.

The impact of terms of trade changes on real domestic income can be estimated using a direct-deflation method. Based on Geary's consolidated system of national accounts (1961, p. 3), consider the nominal external account $N = X - M$, where capital letters indicate nominal flows, $N$ is the trade balance, and $X$ and $M$ are exports and imports. The latter two, being commodity flows, can be deflated to base-year prices in the usual fashion. $N$ can be deflated separately and a trading windfall gain or loss item "$w$" (small letters indicate real flows) can be added to real output to yield real income, at a particular base year. The problem reduces to a method of deflating $N$. Following Gutman (1981, p. 434), a general deflator $P$ is needed in the equation:

$$(1) \qquad w = \text{effects of terms of trade} = (X - M)/P - (x - m),$$

where $x = X/P_x$ with $P_x$ the usual export price deflator, and likewise $m = M/Pm$.

The general deflators fall into two categories: those based on export and/or import prices, and those based instead or additionally on price levels of other economic variables (Geary, 1961, p. 8). Five deflators were tested for South Africa using equation (1): (i) the Nicholson (1960), based on import prices, (ii) the "anti-Nicholson" based on export prices (these two suggest the range of trade-based indicators), (iii) the Tornqvist weighted average of export and import prices (Silver and Mahdavy, 1989, pp. 95-96), (iv) the net domestic expenditure deflator favoured by Stuvel (1959), (v) the CPI, advocated by Scott (1979). With minor fluctuations along the way, they yielded similar results: over the 1956-82 period, at 1975 prices, they varied over a range of one percent in 1956 and 0.1 percent in 1982 (full results are presented in Moll, 1990, pp. 44-45). Looking at the Tornqvist index, it is found that terms of trade losses were common before 1970, averaging 0.5 percent of GDP per annum. The terms of trade gain was largest between 1972 and 1974, averaging 3.3 percent of GDP in each year, and was also above one percent per year between 1977 and 1980. By contrast, drastic losses averaging three percent per annum were suffered in 1975-76 and 1981-82. While these numbers reflect changes in the terms of trade as a whole, the major factor at work was changes in the price of gold.

## 4. Gold Output and Real GDP Growth

The important question, of course, concerns the effects of these methods of estimating the "real" output of the gold mining sector on the growth of GDP.

To begin with, consider the problem of sectoral weights. Where the gold sector's nominal base-year share of GDP changes, its effect on GDP growth rates will change too, following from the use of Laspeyres output indexes. In the pre-1970 period, the gold share of GDP varied little, while the output of fine gold grew slightly faster than GDP, so this effect was small. After 1970 the weighting effect becomes important in the conventional accounts, since due to the slow or negative growth of fine gold output, the higher the weight of gold in the accounting base-year, the lower the measured growth-rate of the economy. Weighting the sectoral "real" output indicators over the 1970–80 period by nominal shares of GDP at different base-years, the conventional GDP growth-rate varies between 3.8 percent per annum at 1970 weights (when the gold share of GDP was 5.5 percent) and 3.0 percent per annum at 1980 weights (when the gold share had risen to 16.1 percent) (sources as for Table 2).

In measuring growth-rates over a period, some kind of typical set of intra-sectoral prices would be useful for weighting indicators, such that the various parts of the economy are "not obviously in violent disequilibrium" and not dominated by an exceptional event (Stone, 1956, p. 106). The year 1980, for example, is a particularly unfortunate choice of base year in South Africa, since due to the gold boom, many markets were seriously out of equilibrium and relative prices and quantities were unrepresentative (as revealed, for example, by a jump in inflation, a sudden appreciation of the real exchange rate, and the temporary high weight of the gold sector).

The simplest approximation to such long-run equilibrium prices is to use base years when prices were fairly typical for periods under analysis. Accordingly, the strategy in Table 2 is to calculate growth rates of various measures of real GDP by weighting real sectoral growth-rates at 1963 prices until 1970, at 1975 prices between 1970 and 1980, and at 1985 prices since.[8] This method reduces the impact of gold sector developments on the rest of the economy, as seen by comparing the first line of the table to the memorandum item. The effects on GDP growth of using all four measures of "real" gold output are shown, as well as the Tornqvist average terms of trade and deflated gross domestic income adjustments. In the last case, the CPI was selected as deflator, the total approximating the volume of goods and services entering into consumer expenditure that could have been purchased at base-year prices.[9]

Until 1970 the real income indicators are close, with various prices moving together; the conventional GDP measure grows fastest (output of fine gold growing more rapidly than non-gold GDP), and the recalculated productive capacity indicator grows slowest (tons of ore milled grew somewhat slower than

[8]The indicators used to measure real sectoral output have been restructured every five years in South Africa since 1970. To calculate sectoral "real" growth-rates, mid-period base-years were used (the national accounts permit no alternative), and these growth-rates were then weighted at 1975 or 1985 sectoral weights.

[9]A more meaningful real income indicator might be national disposable income deflated by the implicit deflator for net domestic expenditure, as recommended by Blades (1989, p. 210). To maintain consistency with the other measures, however, nominal GDP (which is measured on the income side) was deflated instead. The implicit NDE deflator moves in parallel with the CPI, rising at about 0.4 percent per annum faster before 1975, and at about 0.1 percent per annum more slowly since (sources as for Table 2). Due to the CPI's clear meaning and to avoid base-year problems regarding NDE, the CPI was preferred.

TABLE 2

MEASURES OF "REAL" GDP GROWTH IN SOUTH AFRICA 1950–1988

| | Growth rates (% per annum): 1950–70 | 1970–80 | 1980–88 |
|---|---|---|---|
| Conventional real GDP | 4.94 | 3.56 | 1.65 |
| *GDP with gold-sector adjustments*: | | | |
| Recalculated ore-milled version | 4.64 | 4.02 | 2.10 |
| Real gold income (import prices) | 4.79 | 4.82 | 1.05 |
| Real gold income (CPI) | 4.67 | 5.25 | 0.93 |
| *GDP adjustments*: | | | |
| Deflated nominal income | 4.68 | 5.51 | 0.45 |
| Terms of trade adjustment (Tornqvist average) | 4.74 | 4.52 | 1.25 |
| *Memorandum Item* | | | |
| Conventional real GDP (official base years) | 4.94 | 3.31 | 1.49 |

*Sources*: (i) Nominal GDP: CSS, 1989*a*; and South African Reserve Bank, *Quarterly Bulletin*, June 1990; (ii) 1963 base-year data: RSA, 1976, p. 21.7; (iii) 1975 data: RSA, 1982, p. 21.7; (iv) 1980 data: CSS, 1988, 1989b; (v) 1985 data: SARB, *Quarterly Bulletin*, March 1990; CSS, 1989b. Other sources as for Charts 1 and 2.

*Note*: Exponential sectoral growth-rates were calculated at approximate mid-period base-years, and weighted at 1963 weights (1950–70), 1975 weights (1970–80) or 1985 weights (1980–88).

non-gold GDP). The indicators diverge sharply over the 1970s, ranging from deflated nominal income growth of 5.5 percent per annum (real non-gold income rising at 4.5 percent per annum, real gold income rising at 16.4 percent per annum), to the conventional measure of 3.6 percent per annum. The terms of trade gain enjoyed by South Africa was substantial; as per the Tornqvist deflator, the windfall gain averaged one percent of GDP over the decade.

Most of the windfall gains from exports accrued to the gold mining sector, where profits, wages and state tax revenues all boomed (Lombard and Stadler, 1980, chapters 4 and 6). As a rule-of-thumb it is often argued that in a closed economy the economy-wide rate of increase of real wages should not exceed the rate of increase in real output per man-hour, otherwise nominal wage-rises will be inflationary. Notwithstanding theoretical weaknesses, it is clear that terms of trade windfalls escape this rule; if permanent, they may allow (say) a once-and-for-all rise in wages independent of productivity growth, as occurred in South Africa between 1972 and 1975. Problems arise, however, if windfalls are lost, as in South Africa during the early 1980s, when the real income indicators grew more slowly than the conventional one. Between 1980 and 1982, conventional GDP rose by a total of 3.8 percent, compared to a fall of 6.4 percent when GDP is adjusted for changes in the terms of trade. Attempts were made to cut wages, leading to extensive industrial conflict, while as is usual during natural resource slumps, the authorities faced tricky policy dilemmas. It seems the state regarded the gold boom of 1979–81 as permanent, leading to expansionary economic programs being undertaken (e.g. infrastruural projects), often funded by foreign loans, under the assumption of high future gold earnings, and likewise current government expenditure grew. These factors exacerbated the debt crisis when

the dollar gold price fell and real world interest rates rose (Bethlehem, 1988, chapter 3), leading to some years of sharply deflationary macroeconomic policies, thus worsening the economic slowdown of the 1980s.

The GDP growth numbers have implications for economy-wide productivity growth estimation, which can be approximated by the differences between conventional and recalculated growth rates in Table 2. The conventional figures, for example, underestimate the growth of physical productivity in the economy as a whole by around 0.4 percent per annum during the 1970s and 1980s. The analysis also has intriguing implications for the analysis of the post-war political economy of South Africa. Following the conventional national accounting numbers and methodology, for example, Gelb (1991) finds that real GDP grew at 4.9 percent per annum between 1946 and 1974, falling to 1.9 percent per annum over the subsequent dedade (p. 4). Accordingly, he claims the South African economy moved into a crisis phase in the mid-1970s. Using the recalculated GDP index and adjusted weights, these numbers become 4.5 percent and 2.8 percent per annum—a decline far less worthy of the "crisis" label. Taken together, the numbers in Table 2 suggest that the main economic slowdown occurred only in the 1980s.

## 5. Conclusion

As in most countries, the South African national accounting estimates "are done in accordance with international guidelines as prescribed by the United Nations in its Handbook on national accounts" (CSS, 1989c, p, 2). This claim is slightly misleading regarding the measurement of real output, however, as the SNA does not provide "explicit or specific guidance on what the constant price data are supposed to measure" (Hill, 1971, p. 9). The point here is that the national accounting conventions can and should be used flexibility and imaginatively, especially in times of rapid economic change, to provide numbers which are useful in monitoring economic growth and providing inputs into economic policy, as well as catering to more specialised user needs. South African gold mining provides a clear case in which various indicators are necessary to monitor activity in the sector and its effects on economy-wide growth.

This industry is unusual because of its weight in the economy, the role of gold in the world monetary system and its negatively-sloping supply curve due to government supervision. The measurement of real gold output is complex and best gauged using a range of methods, each of which provides valuable insights. The conventional indicator—ounces of gold produced—is precise and has a national accounting role, e.g. in linking the real and nominal accounts. For productivity measurement, the most useful index is tons of gold-bearing ore milled (or productive capacity). However, the physical output numbers should be interpreted in the light of real income trends—measured in various ways—before macroeconomic and distributional implications can be drawn. Finally, base years should be carefully selected to reflect the long-run weight of the gold sector in the national economy. From the national accounting viewpoint, a virtue of this multiple-indicators approach is that the additional numbers can be produced easily and can be fitted neatly into the existing statistical framework.

## References


Adler, H. J., Selected Problems of Welfare and Production in the National Accounts, *Review of Income and Wealth*, 28 (2), 121-132, 1982.

Bethlehem, R. W., *Economics in a Revolutionary Society. Sanctions and the Transformation of South Africa*, A. D. Donker, Johannesburg, 1988.

Blades, D., Revision of the System of National Accounts: A Note on Objectives and Key Issues, *OECD Economic Studies*, 12, 205-219, 1989.

Boyle, G. A., *The Theory of Wasting Assets with Reference to the Regulation and Pricing of Gold in the South African Gold Mining Industry*, M.A. (Economics) thesis, University of Cape Town, Cape Town, 1982.

CSS (Central Statistical Service, Pretoria), GDP at Constant (1980) Prices, computer printout, 1988.

———, GDP at Factor Income at Current Prices, computer printout, 1989a.

———, Written Material on South African National Accounts, 1989b.

———, Letter to author, signed Head, CSS, 1989c.

Chamber of Mines of South Africa, *One-Hundredth Annual Report 1989*, Chamber of Mines of South Africa, Johannesburg, 1990.

Davies, I. S., An Introduction to Gold Mining Taxation, *Investment Analysis Journal* (Investment Analysts Society of Southern Africa, Johannesburg), 20, 47-48, 1982.

Department of Statistics (Pretoria), *Gross Domestic Product at Factor Cost, 1911-1968*, Report 09-01-01, Government Printer, Pretoria, 1970.

Döckel, J. A. and Fourie, L. J., The Sources of Growth in the South African Manufacturing Sector, *Studies in Economics and Econometrics* (University of Stellenbosch), Number 2, 4-18, 1978.

Eisner, Robert, Divergences of Measurement and Theory and Some Implications for Economic Policy. *American Economic Review*, 79 (1), 1-13, 1989.

Franklin, N. N., *Economics in South Africa*, Oxford University Press, London, 1954.

Geary, R. C., Introduction, in Deane, P. (ed), *Studies in Social and Financial Accounting*, 3-8, Bowes and Bowes, London, 1961.

Gelb, Stephen, South Africa's Economic Crisis: An Overview, in Gelb, S. (ed), *South Africa's Economic Crisis*, pp. 1-32, David Philip, Cape Town, 1991.

Gutman, Pierre, The Measurement of Terms of Trade Effects, *Review of Income and Wealth*, 27 (4), 433-453, 1981.

Hill, T. P., *The Measurement of Real Product*, OECD, Brussels, 1971.

Human, J. J., A Review on the Mining Industry of South Africa, *Finance and Trade Review* (Johannesburg), 11 (4), 123-137, 1975.

Kahn, Brian., The Crisis and South Africa's Balance of Payments, in Gelb, S. (ed), *South Africa's Economic Crisis*, pp. 59-87, David Philip, Cape Town, 1991.

Kantor, Brian S., Economic Change, in van Vuuren, D. J., Wiehahn, N. E., Rhoodie, N. J. and Wiechers, M. (eds.), *South Africa: The Challenge of Reform*, pp. 425-454, Owen Burgess Publishers, Cape Town, 1988.

Katzen, Leo, *Gold and the South African Economy*, A. A. Balkema, Cape Town, 1964.

Lombard, J. A. and Stadler, J. J., *The Role of Mining in the South African Economy*, Bureau for Economic Policy and Analysis, University of Pretoria, Pretoria, 1980.

Maas, W. F., Profitability of South Africa's Gold Mines, and the Factors Influencing It, Minerals Bureau Bulletin B18, Department of Mineral and Energy Affairs, Johannsburg, 1990.

Meth, Charles, A Challenge from FOSATU on Productivity, Occasional Paper No. 6, Federation of South African Trade Unions, Durban, 1983.

Moll, Terence, *Output and Productivity Trends in South Africa: Apartheid and Economic Growth*, Ph.D. (economics) thesis, Cambridge University, Cambridge, 1990.

Morgenstern, Oskar, *On the Accuracy of Economic Observations*, second edition, Princeton University Press, Princeton, 1965.

NMC (National Manpower Commission), Gestandaardiseerde Werkgeleentheidsreekse, Werkgeleentheid Volgens Nywerheid, Mimeo, Pretoria, 1989.

National Productivity Institute, *1987 Productivity Statistics*, NPI, Pretoria, 1987.

Nicholson, J. L., Some Problems in the Measurement of Real National Income, in Gilbert, M. and Stone, R. *Income and Wealth*, Volume IV, 145-166, Bowes and Bowes, London, 1955.

———, The Effects of International Trade on the Measurement of Real Income, *Economic Journal*, 70 (279), 608-612, 1960.

President's Council, *Report of the Committee for Economic Affairs on a Strategy and Action Plan to Improve Productivity in the RSA*, PC1/1989, Government Printer, Cape Town, 1989.

Richards, C. S., Problems of Economic Development of the Republic of South Africa, in Robinson, E. A. G. (ed.), *Economic Development for Africa South of the Sahara*, pp. 246-278, Macmillan, London, 1964.

RSA (Republic of South Africa), *South African Statistics 1976*, Government Printer, Pretoria, 1976.
———, *South African Statistics 1982*, Government Printer, Pretoria, 1982.
———, *South African Statistics 1988*, Government Printer, Pretoria, 1988.
SARB (South African Reserve Bank), *A Statistical Presentation of South Africa's National Accounts for the Period 1946 to 1980*, Supplement to SARB *Quarterly Bulletin* (September), 1981.
Scott, M. F. G., What Price the National Income? in Boskin, J. (ed,), *Economics and Human Welfare: Essays in Homour of Tibor Scitovsky*, pp. 163-182, Academic Press, New York, 1979.
Silver, M. and Mahdavy, K., The Measurement of a Nation's Terms of Trade Effect and Real National Disposable Income within a National Accounting Framework, *Journal of the Royal Statistical Society*, Series A, Volume 152 (1), 87-107, 1989.
Stear, W., Gold Mining in South Africa—Where To? *Mining Survey* (Chamber of Mines of South Africa, Johannesburg), 1, 3-6, 1988.
Stone, Richard, *Quantity and Price Indexes in National Accounts*, OECD, Paris, 1956.
Storrar, C. D. *et al. South African Mine Valuation*, Johannesburg, Chamber of Mines of South Africa.
Stuvel, G., Asset Revaluation and Terms-of-trade Effects in the Framework of the National Accounts, *Economic Journal*, 69 (274), 275-292, 1959.
Wagner, Horst and Reinoud Boers, Productivity in the South African Mining Industry, *Mining Survey* (Chamber of Mines of South Africa, Johannesurg), Number 2/3, 15-19, 1988.
Wallace, R. E. and Robertson, A. S., *Economics of South African Gold Mining*, Radford Adlington, Johannesburg, 1951.
Willers, J. J. D. and Groenewald, B. P., Problems Raised by the Calculation of Real National Income in South Africa, in Samuels, L. H. (ed.), *African Studies in Income and Wealth*, pp. 182-205, Bowes and Bowes, London, 1963.