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ACCOUNTING FOR MINERAL RESOURCES IN TANZANIA: DATA CHALLENGES AND IMPLICATION FOR RESOURCE MANAGEMENT POLICY

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ABSTRACT

Total wealth is defined to include produced, natural and human capital. In developing measures of sustainability, current systems of national accounts (SNA) capture produced but not natural and human capital. The system of environmental and economic accounts (SEEA) was introduced to correct for this omission of natural capital in SNA. This study implements the SEEA to Tanzania minerals' sector. Data collection efforts enabled construction of physical accounts for gold, coal and natural gas. Due to lack of data, World Bank unit rent estimates used to estimate the economic accounts. Unit rent disaggregated into capital and income components to make recommendations on sustainable use of mineral revenues among other recommendations.

Key words: resource accounting theory, applications, Tanzania, data

1. Introduction

There is a new line of thinking in development and growth theory demonstrating that sustainable development requires non-declining per capita wealth (World Bank 2006, Lange 2004 & 2005, Hamilton & Clemens 1999). In this conceptualization, wealth is defined in a very broad sense to include produced, natural and human (including social) capital. The challenge posed by this approach to growth and development is for economies to manage their asset portfolios so as to realize the objectives of sustainability (non-declining per capita wealth). This requires economies to have the ability to monitor total per capita wealth and analyze changes in this indicator (e.g., Lange 2004). It is well known that the current system of national accounts (SNA) does not adequately represent natural (and human) capital stocks, and the consequences of this omission (neglect) have been well documented (e.g., World Bank 2006, Lange 2004 & 2005, Hamilton & Clemens 1999). However, there presently exists a standardized framework (and methodologies) for constructing environmental accounts, called the system of integrated environmental and economic accounts, or SEEA (UN et al 2003), which extends the asset boundary of the SNA to include all natural resources, recording asset value, depletion and improvements in the stock of natural capital (Lange 2004). The results from implementing the SEEA could potentially be used to better represent natural assets in the SNA and by so doing develop improved indicators of sustainability.

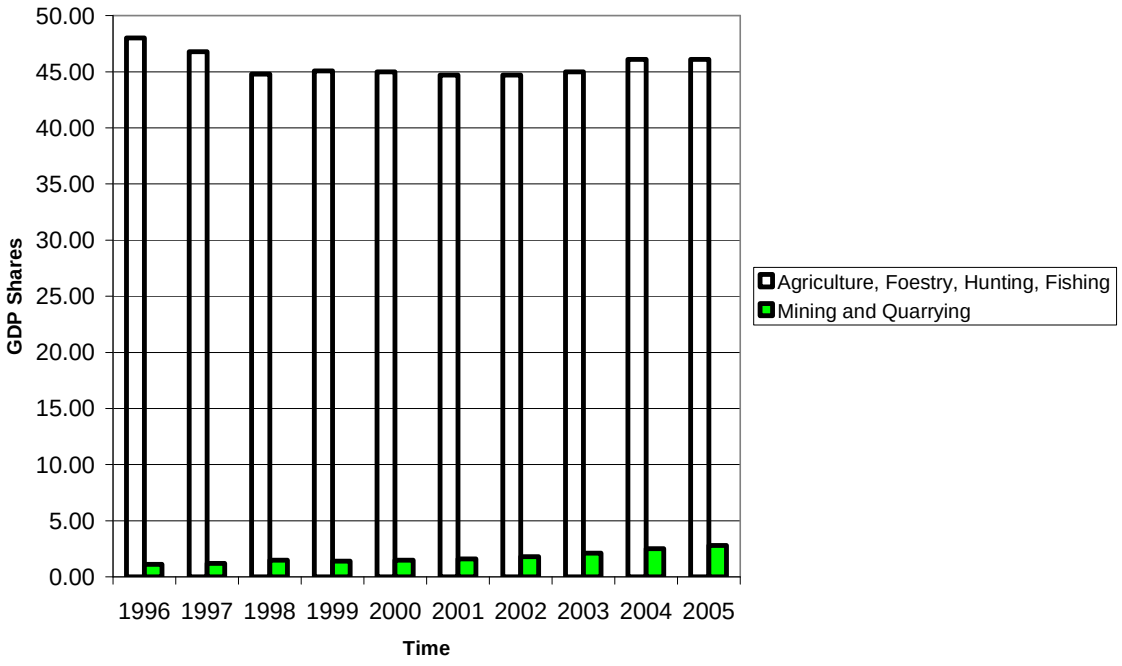
In this paper, we attempt to measure the value of important subsoil assets of Tanzania as a first step towards developing more comprehensive measures of total national wealth. Tanzania is endowed with a rich array of minerals including precious metals (e.g., gold, silver, platinum)[1], none-metallic colored stones (e.g., tanzanite), base metals (e.g., lead, copper, tin, zinc), fibrous minerals (e.g., asbestos), amorphous materials and mineral fuels (petroleum, natural gas, coal) and a range of industrial rocks and minerals[2]. Appendix 1 shows mineral recoveries for the period 1995-2005. It is clear from the appendix that gold, diamonds and gemstones (especially tanzanite) are particularly important.

Although mining and quarrying in Tanzania are not domestically very large (Figure 1), they play a particularly important role in export earnings. Figure 2 shows that between 1998 and 2005, Tanzania witnessed a dramatic change in the composition of export GDP. While in 1998

[1] Tanzania is the third largest producer of gold in Africa after South Africa and Ghana
[2] http://www.tanzania.go.tz/

traditional export commodities[3] accounted for 61% of the value of exports (with non-traditional commodities[4] accounting for 39%), by 2005 the former accounted for only 21% while the later accounted for 79%. Much more important is the observation that the composition of non-traditional export commodities also changed during this period. While minerals accounted for only 11% of these in 1998 (with other exports accounting for a mega 73%), by 2005, minerals accounted for 54% while the value of other exports had dropped down to 34% (Figure 3). Recent statistics show that the share of minerals in export GDP continues to rise, thus clearly manifesting the growing importance of minerals in the export revenues of Tanzania.

Figure 1 GDP shares of the two primary sectors, Tanzania, 1996-2005



[3] Traditional export commodities: coffee, cotton, sisal, tea, tobacco, cashew nuts and cloves
[4] Non-traditional export commodities: petroleum products, minerals, manufactured goods and others

Figure 2 Shares of traditional and non-traditional commodities in export GDP, Tanzania, 1998-2005

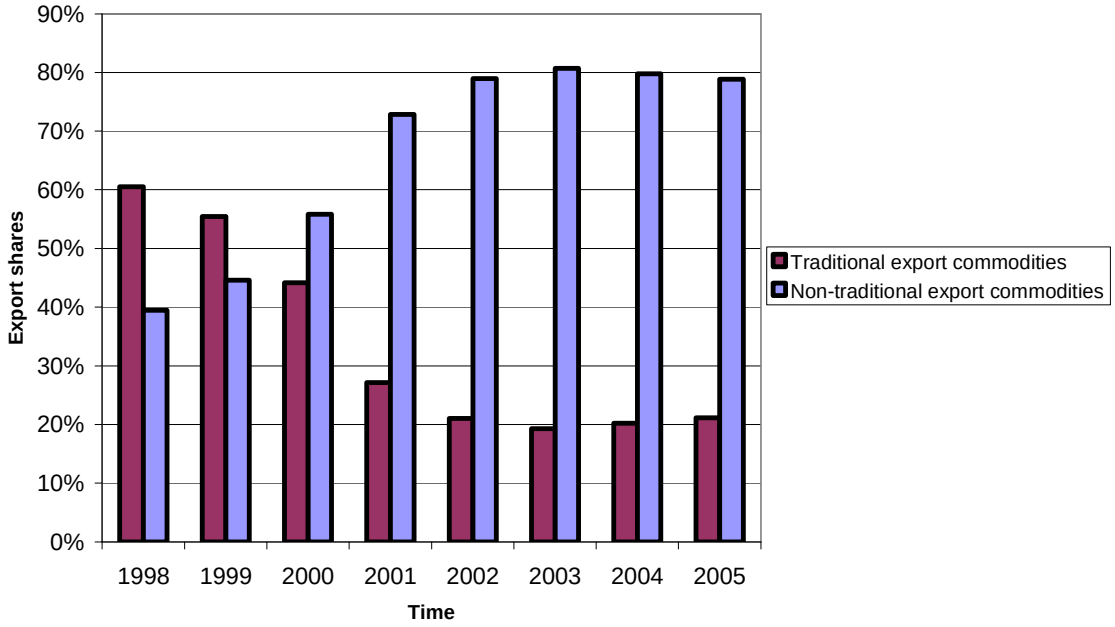
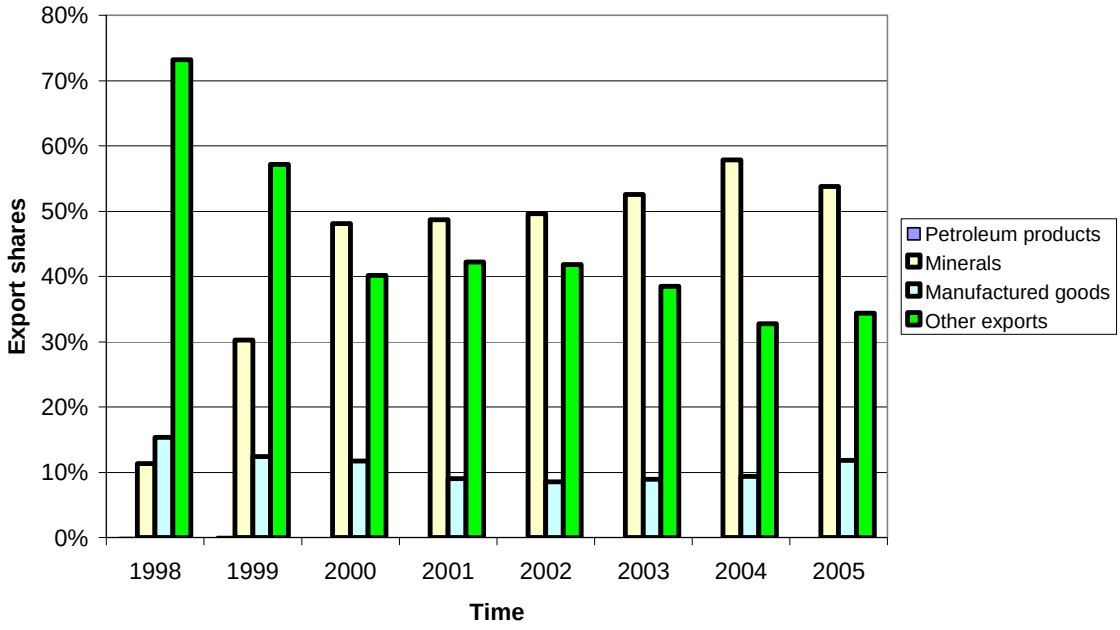


Figure 3 Changes in the composition of non-traditional commodities to export GDP, Tanzania, 1998-2005



Domestically, the mining and minerals sector raises revenues for government through royalties and taxes; provides employment; mining companies are known to invest in the provision of roads, water infrastructure, health facilities among other developments in the rural areas they operate in (on these see the report on the Tanzania mineral accounts, CEEPA 2007). All this evidence point to the fact that minerals are important to the welfare of Tanzania and it is in the interest of government to implement policies that guarantee that they are depleted in a manner that support the objectives of economic sustainability.

The main objective of this paper is to estimate the value of Tanzania's mineral reserves using the SEEA methodology. As state earlier, this is a step in measuring total wealth, which forms the basis for assessing whether development is sustainable or not. To the best of our knowledge, such a study has not been implemented in Tanzania before. Other studies that have compiled mineral accounts in sub-Saharan Africa using the SEEA methodology include Blignaut and Hassan (2002), Lange (2004) and more recently, Stats SA (2008). The balance of this paper is structured as follows: section 2 provides a review of the UN SEEA framework for minerals. The data and methods used to compile the accounts are presented in section 3, results and discussions in section 4 and finally the policy applications in section 5.

2. The SEEA framework for minerals

Generic environment and natural resource accounts have four basic components (e.g., see Lange et al 2003):

1. Natural resource asset accounts, which are stocks of natural resources constructed to revise the balance sheets of the SNA and improve resource management. These measure stock levels at the beginning and end of the accounting period, and evaluate the changes in stock levels over the period.
2. Pollutant and material (energy and resource) flow accounts, which provide information at the industry level about the use of energy and materials as inputs to production and final demand, and the generation of pollutants and solid waste. These accounts are linked to the supply and use tables of the SNA, which are used to construct input-output tables and social accounting matrices.
3. Environmental protection and resource management expenditure accounts, which identify expenditures in the conventional SNA incurred by industry, government and households to protect the environment or manage resources.

4. Environmentally adjusted macroeconomic aggregates, which include indicators of sustainability such as environmentally adjusted net domestic product (eaNDP).

Data permitting, it would be ideal to construct all these accounts. However in this study, we only concentrate on the first component due to data limitations. Table 1 gives an example of the application of the physical asset accounts for diamonds of Botswana (Lange 1990).

Table 1. Physical asset accounts for diamonds, 1980 to 1999 (millions of carats)

	Opening Stocks	Extraction	New Discoveries	Other volume changes	Closing stocks
1980	1,053	5.1	Na	Na	1,048
1981	1,048	5.0	Na	Na	1,043
1982	1,043	7.8	Na	Na	1,035
1983	1,035	10.7	Na	Na	1,024
1984	1,024	12.9	Na	Na	1,012
1985	1,012	12.6	Na	Na	999
1986	999	13.1	Na	Na	986
1987	986	13.2	Na	Na	973
1988	973	15.2	Na	Na	957
1989	957	15.3	Na	Na	942
1990	942	17.4	Na	Na	925
1991	925	16.5	Na	Na	908
1992	908	15.9	Na	Na	892
1993	892	14.7	Na	Na	878
1994	878	15.6	Na	Na	862
1995	862	16.8	Na	Na	845
1996	845	17.7	Na	Na	828
1997	828	20.1	Na	Na	807
1998	807	19.8	Na	Na	788
1999	788	20.7	Na	Na	767

Source: Lange (1990)

Monetary accounts ideally should convert the information provided by physical accounts (e.g. table 1 above) into commensurate monetary values. To compile the monetary accounts, one has to monetarily value each of the column entries. In the SNA, the preferred method for asset valuation is based on the prices realized in market transactions at the time to which the balance sheet relates (e.g. Eurostat 2000). When market prices do not exist, valuation is done by calculating the net present value of future resource rents (e.g. Lange et al 2004, Eurostat 2000). Three steps are involved in calculating the net present value of future resource rents:

1. Estimate the level of the resource rent in the current period;
2. Project the resource rent into the future;
3. Discount the set of future resource rents to a value in the present period.

Current resource rent is calculated as the difference between total revenues and total costs, where the later consists of intermediate consumption, compensation of employees, consumption of fixed capital and normal profit (e.g. Lange 2004).

$$R_t = TR_t - IC_t - CE_t - CFC_t - NP_t \quad (1)$$

$$NP_t = i_t K_t \quad (2)$$

R	= the resource rent
TR	= total revenue from the mining sector
IC	= intermediate consumption
CE	= compensation of employees
CFC	= consumption of fixed capital
NP	= 'normal profit', a return to fixed capital
K	= fixed capital stock invested in an industry
i	= the rate of investment considered the opportunity cost of capital

Projecting the resource rent into the future depends on a number of parameters including the number of years the mine will remain in operation; how the number of years will be affected if the extraction rate alters; the effect of new discoveries on the expected life length of the mine and what would happen to the projections if the unit resource rent was to varies (Eurostat 2000). The formula for calculating the net present value of mineral assets V at period τ is:

$$V_\tau = \sum_{t=\tau}^{T} \frac{p_t Q_t}{(1+r)^t} \quad (3)$$

$$p_t = \frac{R_t}{Q_t} \quad (4)$$

$$T_t = \frac{S_t}{Q_t} \quad (5)$$

V = value of the asset

p = unit rent price of the resource

Q = quantity of resource extracted

r = the discount rate

R = total resource rent

T = the remaining lifespan of the resource

S = the stock of mineral reserves at the close of the accounting period

3. Important minerals of Tanzania

Several factors were considered in selecting the mineral assets to be included in the accounts: social importance, economic importance and data availability. We stated in the introduction that although Tanzania is endowed with a rich array of minerals, gold, diamonds and gemstones (especially tanzanite) are of greater social and economic significance given current extraction technology and economic conditions. In a later section we will show that coal and natural gas were also included on account of data availability.

Information obtained from a variety of sources indicates the following firms are actively involved in mining for gold[5]: Resolute Mining, Geita Gold, Kahama Mining, Placer Dome, Meremeta, Barrick Gold Corp & MDN, Northern Mining and Gallery Gold. *Resolute Mining Ltd* of Australia owns the Golden Pride Mine through its Tanzanian subsidiary, Resolute (Tanzania) Ltd (started production in 1998). *Geita Gold Mining Ltd* operates the Geita Mine (started production in 2000, USGS 2001), which was initially owned 50% by Ashanti of Ghana and 50% by Anglo Gold of

[5]For example: http://www.tanzaniagold.com/ (22.01.2009)

South Africa (USGS 2003). In 2004, the two companies merged to form the AngloGold Ashanti Ltd (USGS 2004). *Kahama Mining Corp Ltd* (a subsidiary of Barrick Gold Corp) owns the Bulyanhulu Mine, which started commercial production in 2001 (Global InfoMine 2005). *Placer Dome Gold Inc* owns the North Mara mine (started production in 2002). *Meremeta Ltd* owns the Buhemba Mine, which started production in 2003 (USGS 2003). *Barrick Gold Corp & MDN of Canada* own the Tulawaka Mine and 14 prospecting licenses, 3 of which are held by Tan Range while the remaining 11 are held by *Northern Mining and Exploration* (USGS 2003). *Gallery Gold Ltd* owns the Kitongo Mine and is also doing some exploration in the Buckreef deposits where no production has so far been reported. In addition to large-scale mining, there are many small-scale mines scattered across the country: around Lake Victoria in the north-west (Kagera, Mwanza, Musoma, Shinyanga and Tabora regions), in the southern highlands (Ruvuma, Mbeya and Rukwa regions), in the central part (Singida and Dodoma regions), in the northern part, in the Tanga region, and in the southern part (Mtwara region).

There are two large scale diamond companies operating in Tanzania, both situated in Mwadui: *Williamson Diamonds Ltd* and *Hillal Minerals Ltd*. The former was for a long time owned 75% by DeBeers and 25% by Government of Tanzania (GoT). However in 2008, DeBeers sold its shares to Petra Diamonds Ltd[6]. The later, which was established in 1993 after GoT liberalized the mining sector, is wholly owned by GoT[7] (Mwadui News, 2005).

The world's only known source of tanzanite is situated in Tanzania[8]. Geological tests reveal supply will be exhausted in the next 15 to 20 years given current technology and exploitation. In 1990, GoT demarcated the area where tanzanite is mined into Blocks A, B, C and D to regulate its exploitation by both large scale and artisanal miners[9]. Blocks A and C were allocated to two large scale producers, *Kilimanjaro Mines* and *Graphtan Ltd* respectively[10], while Blocks B and D were allocated to small scale miners. *Graphtan* ceased its activities in 1996, subsequent to which *Afgem* acquired its license. In 2000, *Afgem* completed a feasibility study for the commercial mining of tanzanite and mine development commenced in 2001. *Afgem* sold its tanzanite business and assets to *TanzaniteOne (SA) (Proprietary) Ltd* in 2004, which in the same year changed its status from private to the public company, *TanzaniteOne (SA) Ltd*.

[6] http://kurayangu.com/ipp/guardian/2008/09/10/122288.htmlb (22.01.2009)
[7] http://www.mwadui.co.uk/ (22.01.2009)
[8] http://www.tanzaniteone.com/ (22.01.2009)
[9] E.g. see http://www.tanzaniteone.com/ (22.01.2009)
[10] Graphtan Limited is a graphite mining company; graphite is a byproduct of tanzanite

Coal, presently mined from Kiwira, is one of the major energy resources of Tanzania. Kiwira started production in 1998 and currently supplies 6MW of power to the national grid. There are plans to expand its capacity to 30MW under a joint venture with a Chinese company[11]. There are also coal reserves at Mchuchuma with plans to develop these for power generation foreseen beginning 2018. It is expected that Mchuchuma will add 400MW to the national grid.

The most important natural gas discoveries in Tanzania are located in Songo Songo (Lindi) and Mnazi Bay (Mtwara), with reserves estimated at 30 and 15 billion cubic meters, respectively (DEA 2005). The Songo Songo reserves have apparently been developed (gas to electricity project commissioned in 2004) supplying natural gas for power generation in Dar-es-Salaam thus adding 192 MW to the national grid (MEM 2004). The Mnazi Bay reserves are yet to be developed.

4. Data and methods

4.1 Data for physical accounts

In countries where sub-soil assets form an important component of national wealth (and with a history of constructing NRA), there is usually a standardized code used for reserve and resource classification and reporting (e.g., see Blignaut & Crafford 2007). Unfortunately at the time of this study, the Tanzania Ministry of Minerals and Energy did not avail such a code (or guidelines). As a result, there were no figures for reserves and resources for all the minerals in Tanzania and consequently, we resorted to the United States Geological Survey (USGS)[12] data base to produce this report.

USGS provides data for gold reserves and resources for the period 1994-2004, in some instances by mining company and others by mine[13]. In this report, we attempted to compile the data by mining company before aggregating it to the industry. However, this process encountered several difficulties. Before 2001, USGS reported data by mining company and the properties from which a company was licensed to explore. Thus in 1997 for example, Samax Resources Ltd (UK) reported reserves and resources for Geita and in the same report, Ashanti (Ghana) reported

[11] China Hunan International Economic and Technical Cooperation Corporation
[12] http://minerals.usgs.gov/minerals/pubs/country/africa.html.
[13] This is not a criticism but a reflection of the fact that USGS collects data for its own purposes and not for constructing natural resource accounts. The NRA compiler has to use the available data and package it in a form consistent with the NRA reporting framework.

reserves and resource for Geita. It was thus not clear whether the two should be added to obtain a single figure. Where we encountered this problem, we used the larger of the figures to minimize the influence of double-counting on the results. It was only after 2001 that USGS consistently reported by mining company. Second, reporting on the locations where mineral exploration was taking place is not easily tractable through time. In particular, USGS reports on locations without giving other details that could help an analyst identify the same location in subsequent years. A location could be mentioned in a given year and then it does not feature in any of the subsequent USGS reports. This makes compiling a time series of reserves and resources by location of exploration difficult. In some instances, the properties where exploration was taking place were owned as joint-ventures, further complicating the compilation of reserves and resources by the company with the rights to exploit. There also were many changes in the ownership of exploration and mining licenses beginning 1994 making the task of constructing a timeline for reserves and resources by mining company difficult. Finally, the USGS data before 1999 is generally provided without much detailed. As a consequence, the figures for reserves and resources we report on before 2001 may be subject to interpretation errors on our part.

Coal reserves, resources and production were obtained from several sources including Ministry of Energy and Minerals[14], DEA (2005), URT Economic Survey (2005)[15] and USGS. Natural gas reserves were obtained from the Ministry of Energy and Minerals and USGS. Natural gas production was obtained from USGS (only for 1 year). At the time of the study, there was no published data for diamond reserves and resources from all possible sources we contacted. We were officially informed from the Ministry that for gemstones like diamond and tanzanite, it is difficult to make such an assessment of availability using conventional[16]. The only available estimate for diamond reserves in Tanzania was 3.8 million carats (USGS, 1994) and these were reported only once. Although we also never obtained resources and reserves for tanzanite, TanzaniteOne (2005) reports: *"although reserve and resource figures have been prepared, reviewed and verified by independent mining experts, these values, given the unique operating environment, remain best estimates only. The Group continues to make efforts to further refine its interpretation and understanding of the ore body"*. This report indicated resources of 60-80 million carats with a potential value of +US$ 2 billion.

[14] http://www.tanzania.go.tz/energy.htm (27.01.2009)
[15] http://www.tanzania.go.tz/economicsurveyf.html (27.01.2009)
[16] In as much as this might be true, this does not explain how a firm decides to invest in diamond mining without knowledge of the size of reserves.

We know from section 2 that the minimum requirement for implementing the SEEA framework is reserve and/or resources data. Consequently we were only able to compile physical resource accounts for gold, coal and natural gas.

4.2 Data for Monetary Accounts

To estimate monetary accounts, one has to implement the SEEA methodology for resource rent calculation (equation 1) and then use it for asset valuation (equation 3). Usually one would expect to obtain all information required to calculate resource rent from national accounts. Unfortunately the Tanzania National Bureau of Statistics (NBS), in presenting the national accounts, reports the gross operating surplus (GoS) of mining and quarrying together making it impossible to isolate mining GoS. In addition, even if it was possible to isolate mining GoS, what we required for asset valuation were individual estimates of resource rent for gold, coal and natural gas. An alternative to using national accounting data was to use data from the Tanzania industrial survey. However, strict confidentiality ruled out this possibility. As a result we resorted to the World Bank (2002) estimates of resource rents to enable asset valuation[17]. The methodology the World Bank uses for estimating resource rents is reported in "*Manual for Calculating Adjusted Net Savings* (Bolt et al 2002)", where we only found resource rent estimates for coal and gold. Consequently, our asset valuation is limited to these two minerals.

Bolt et al (2002) calculate resource rent as the international market price of extracted material minus average production cost. In applying this methodology to coal, international export prices of steam and coking coal, adjusted to reflect the same net calorific value, were used to estimate an average world price. The international export prices were obtained from the International Energy Agency statistics (2001). In general, export prices are bound to be higher than the prices for locally sold coal. Bolt et al (2002) do not present data for average production cost in Tanzania. According to their methodology, for those countries for which no production cost data was available, a surrogate from another country was used. The surrogate in the case of Tanzania was the world average, computed from the average costs of production for Australia, USA, Canada, Colombia, South Africa, Indonesia, Poland, Czech Republic, China, Russia, Mexico and India. It is clear that the average production costs used in the World Bank resource rent estimates are bound to be higher than those obtaining in Tanzania, where labor is much cheaper. However

17 http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTEEI/0,,contentMDK:20487828~menuPK:1187788~pagePK:148956~piPK:216618~theSitePK:408050,00.html

without more information, it is not possible to unilaterally assess whether the World Bank estimates are higher or lower than the "true" estimates, although intuition suggests that these might be over-estimates. All unit rent estimates were recorded in current US$/ton (Table 2).

In applying this methodology to gold, Bolt et al (2002) recognize that production costs for metals and minerals are proprietary information and very difficult to obtain, which probably goes to explain why we could not get this information locally in Tanzania. Bolt et al (2002) obtained price data from the United Nations Conference on Trade and Development (UNCTAD) monthly commodity price bulletin. They however had no data for average production cost for Tanzania. They instead used the average cost for market economies. Following the reasoning above for coal, the World Bank gold resource rent estimates for Tanzania are likely to be above the "true" estimates. All unit rent estimates were recorded in current US$/ounce (Table 2).

Table 2. Unit rent estimates for gold and coal

	Gold (Unit Rent)		Coal (Unit Rent)	
Year	($/Ounce)	($/ton metric)	($/ton)	($/million ton)
1990	80.94	2,855,073.84		
1991	49.18	1,734,779.54		
1992	23.54	830,259.55		
1993	32.23	1,136,942.16	3.08	3,080,000
1994	49.47	1,745,031.49	2.56	2,560,000
1995	42.76	1,508,183.09	3.44	3,440,000
1996	39.82	1,404,418.21	3.40	3,400,000
1997	33.17	1,169,940.05	2.70	2,700,000
1998	31.33	1,105,204.74	2.03	2,030,000
1999	30.64	1,080,690.27	1.40	1,400,000
2000	29.61	1,044,454.02	1.17	1,170,000
2001	28.48	1,004,439.19	1.90	1,900,000
2002	32.72	1,154,148.50	1.85	1,850,000
2003	38.76	1,367,301.51	2.01	2,010,000
2004	8.89	313,579.58	2.05	2,050,000

5. Results and discussion

5.1 Physical accounts

The physical accounts for gold are presented in Table 3.

Table 3. Physical accounts for gold in Tanzania, 1990-2004 in metric tons

Year	Opening Stocks		Production	Changes		Closing Stocks	
	Reserves	Resources		Reserves	Resources	Reserves	Resources
1990	751.801	NA	3.500	NA	NA	748.301	NA
1991	748.301	NA	3.851	NA	NA	744.450	NA
1992	744.450	NA	3.201	NA	NA	741.249	NA
1993	741.249	NA	3.264	NA	NA	737.985	NA
1994	737.985	NA	2.861	NA	NA	735.124	NA
1995	735.124	NA	0.320	NA	NA	734.804	NA
1996	734.804	NA	0.318	NA	NA	734.486	NA
1997	734.486	NA	0.232	NA	NA	734.254	NA
1998	734.254	NA	0.427	NA	NA	733.827	NA
1999	733.827	NA	4.767	NA	NA	729.060	NA
2000	729.060	NA	15.060	NA	NA	714.000	NA
2001	714.000	1,050	29.785	97	97	781.000	1,147
2002	781.000	1,147	35.632	26	79	771.000	1,200
2003	771.000	1,200	40.768	45	10	775.00	1,202
2004	775.000	1,202	43.666	NA	NA	NA	NA

- NA means the figure is not available

The physical accounts for coal are presented in Table 4.

Table 4 Physical accounts for coal in Tanzania, 1993-2004 in million tons

Year	Opening stocks (proven economic reserves)	Production	Changes	Closing stocks (proven economic reserves)
1993	140.00	0.04	NA	139.96
1994	139.96	0.05	NA	139.91
1995	139.91	0.04	NA	139.87
1996	139.87	0.05	NA	139.82
1997	139.82	0.03	NA	139.79
1998	139.97	0.05	NA	139.75
1999	139.75	0.08	NA	139.67
2000	139.67	0.08	NA	139.59
2001	139.59	0.08	NA	139.51
2002	139.51	0.08	NA	139.43
2003	139.43	0.05	NA	139.38
2004	139.38	0.07	NA	139.32

- All figures are expressed in tons millions

The physical accounts for natural gas are presented in Table 5.

Table 5 Physical accounts for natural gas in Tanzania, 1993-2004 in billion cubic feet

Year	Opening stocks (proven economic reserves)	Production	Changes	Closing stocks (proven economic reserves)
1993	968	NA	NA	968
1994	968	NA	NA	968
1995	968	NA	NA	968
1996	968	NA	NA	968
1997	968	NA	NA	968
1998	968	NA	NA	968
1999	968	NA	NA	968
2000	968	NA	NA	968
2001	968	NA	NA	968
2002	968	NA	NA	968
2003	968	NA	NA	968
2004	968	4.2024	NA	963.7976

- USGS (2004) reports that production of natural gas in 2004 was 119 million cubic meters which translates to 4.2024 cubic feet.

5.2 Monetary accounts

Two simplifying assumptions were used in implementing the equation for asset valuation (e.g. Lange et al 2004). First, we assumed that extraction will continue at current levels up to the date of mineral depletion. Second, we assumed that the resource rent will remain constant at today's levels through depletion. According to the Bank of Tanzania[18] , the discount rate in December 1999 was a high 20.2% while that of December 2003 was a low 12.3%. The Tanzania Economic Survey (2005) reports the average rate of inflation in 2004 was 4.2%. Consequently, we hypothesize that a social rate of discount of between 5% and 8% would be appropriate for asset valuation. In this study, we present our monetary accounts using two rates of discount, 5% and 10% to test whether the resulting asset value estimates are sensitive to the choice of discount rate. Further, the discount rate was held constant through the accounting period as a simplifying assumption. We present the monetary accounts using the current resource rent (the rent calculated for each year) and using a 5-year moving average to reflect the fact that mineral prices can fluctuate a great deal from one year such that the real value of mineral assets is not always best represented by the unit rent in any single year (e.g. see Lange 1990). The detailed monetary accounts for gold and coal are presented in appendices 2 and 3 respectively. In what follows, we just highlight the main results.

A number of general statements can be made from the results summarized in Figures 4-7. First, it is clear that the asset value of gold in Tanzania is by orders of magnitude much higher than that of coal. This is not surprising since Tanzania has such huge reserves of coal meaning that these resources are going to be used far into the future making their current values very low. This is very important, because it means that in the context of resource management, Tanzania has to pay particular attention to the prudent management of the revenues deriving from the exploitation of gold. Second, the results also show that the present value of the stocks of gold increase with time while that of coal remains more or less constant. This could possibly be a manifestation of the fact that the assets become more valuable with time because of scarcity. The size of the coal reserves on the other hand is massive relative to current extraction rate such that current extraction rates virtually have no impact on the reserves. Third, there does not seem to be much difference in the behavior of the series, when measured at current prices and when measured

[18] http://www.bot-tz.org/

using the 5-year moving average. The 5-year moving average was expected to smoothen the trends. This could possible be a reflection of the resource rent estimates used in these calculations. Finally, the asset values with the 5% and 10% rates of discount are consistent with theoretical expectations.

Figure 4 Monetary Accounts for Gold in Tanzania, 1990-2004, millions US$ Current

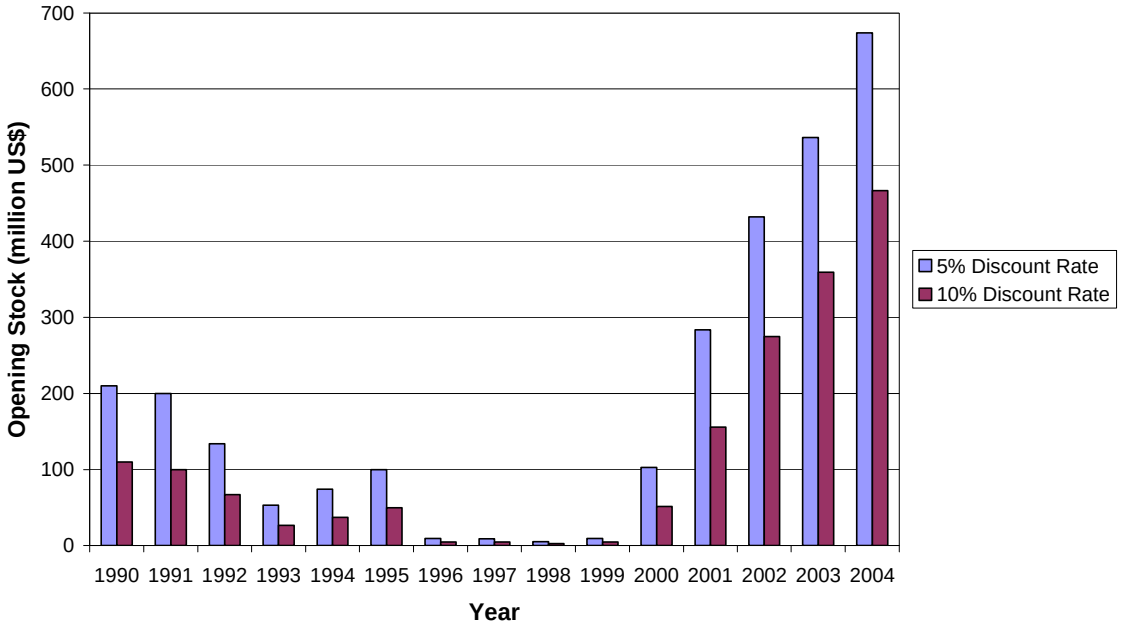


Figure 5 Monetary Accounts for Gold in Tanzania, 1990-2004, millions US$ 5-Year Moving Average

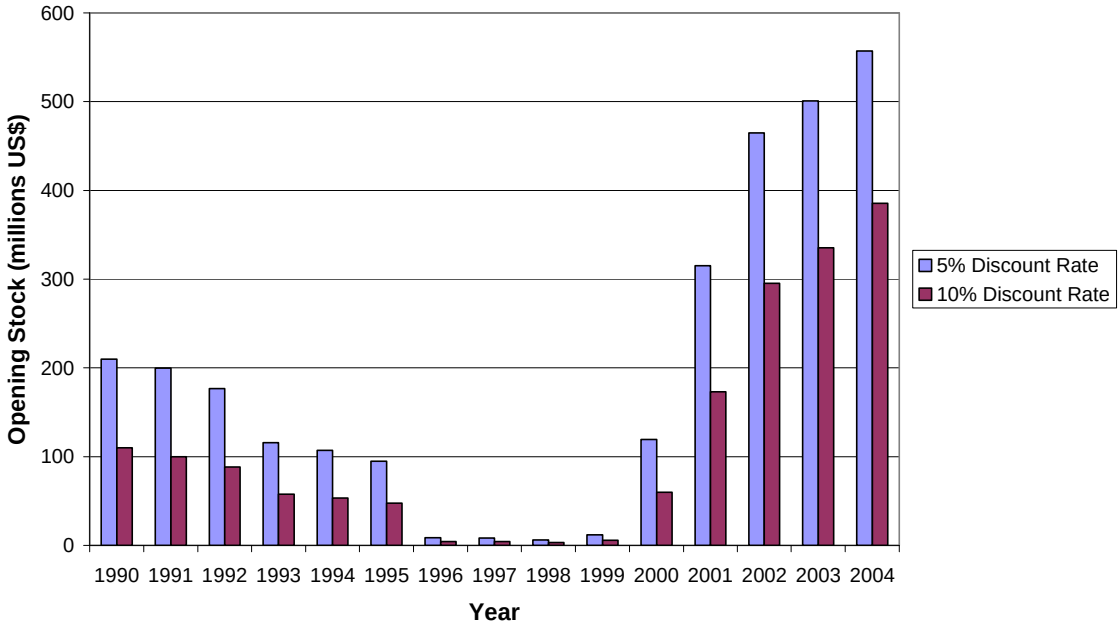


Figure 6 Monetary Accounts for Coal in Tanzania, 1993-2004, millions US$ Current

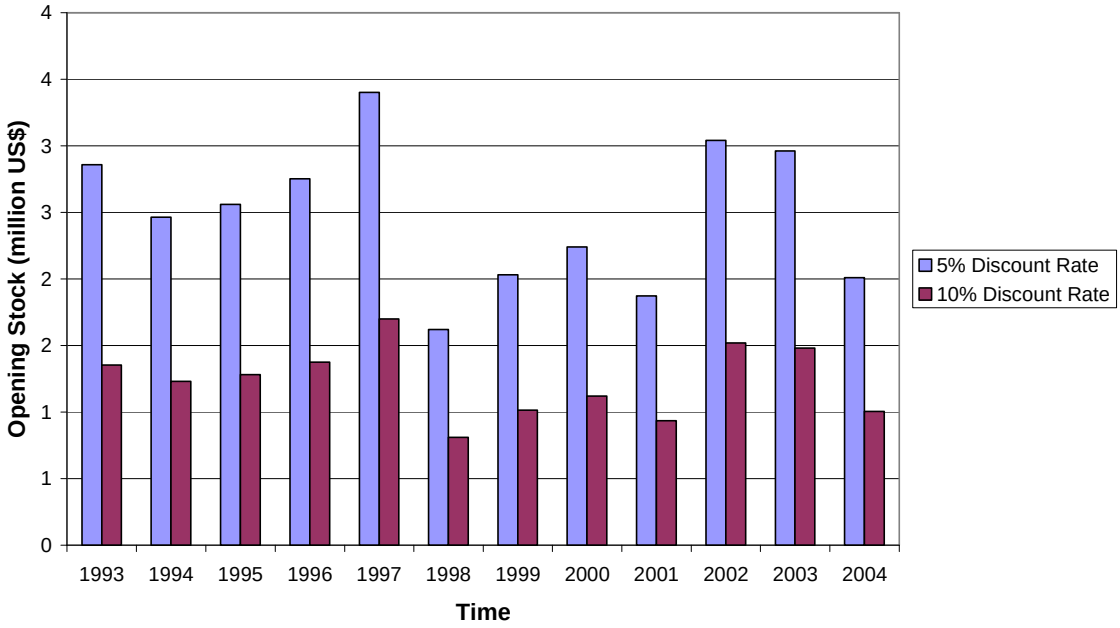
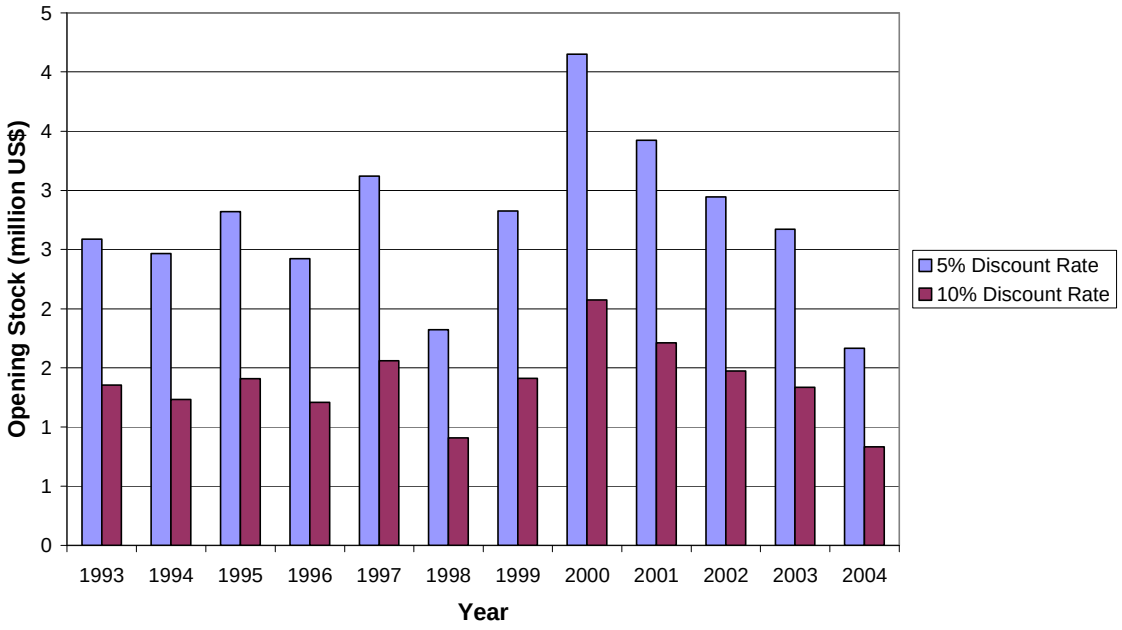


Figure 7 Monetary Accounts for Coal in Tanzania, 1993-2004, millions US$, 5-Year Moving Average



6. Policy implication

Before we comment on the policy implications of our study, we would like to explicitly recognize that there are a number of problems with our results that relate directly to the number of assumptions we had to make to obtain them. In our opinion, although the assumptions we made on the physical accounts might not severely impact on our subsequent prescriptions, the ones we made in calculating the resource rent are likely to. Consequently, the real importance of our results lies in demonstrating that even in countries where there are severe institutional and data problems, values of important natural assets can still be derived. To the extent we are able to convince government that there are enormous benefits to be reaped by society and by the resource (in terms of resource management policy) from this kind of research, our results points the way for later developments. A logical way to proceed would then be to convince government to sequentially remove the hurdles that stood in the way of estimating the resource accounts and see if this would lead to better estimates for the benefits of society and the resources in question.

As stated at the beginning of this paper, the basic reason that we construct environmental accounts is to enable countries estimate the value of their natural assets (minerals, forests, fisheries etc), information can then be used in deriving more comprehensive measures of genuine

savings (e.g. see Bolt et al 2002). With such a measure, it is possible to make an assessment of whether a country is following a sustainable path. In as much as this study cannot provide such a measure as a stand alone, it should be considered as a first step towards developing such a measure for Tanzania. It is hoped that as Tanzania develops resource accounts for other assets, it would be possible in future to estimate the total wealth, as has been the case in Namibia, for example (see Lange 1990).

Another important policy application of a study of this type is to asses whether the minerals sector in Tanzania is currently being managed so as to satisfy the objectives of sustainability. It is well-known from the wealth accounting literature that to sustain welfare from the exploitation of an exhaustible resource, a proportion of the resource rent must be invested in other substitute forms of capital. El Serafy (1989) derives the following relationship to decompose the total resource rent (R_t) into its capital component $(R_t - X_t)$ as the proportion that needs to be reinvested and its income component X_t as the proportion that can be consumed:

$$X_t = R_t\left(1 - \frac{1}{(1+r)^{N+1}}\right) \qquad (7)$$

where r is the rate of return and N is the number of years extraction can take place at the current rate. Table 6 shows the results of applying the El Serafy decomposition to the gold and coal rents for Tanzania.

Table 6 Capital Component of Resource Rent (1990-2004) at 5% and 10% rates of discount

Year	Gold		Coal	
	5%	10%	5%	10%
1990	0%	0%		
1991	0%	0%		
1992	0%	0%		
1993	0%	0%	0%	0%
1994	0%	0%	0%	0%
1995	0%	0%	0%	0%
1996	0%	0%	0%	0%
1997	0%	0%	0%	0%
1998	0%	0%	0%	0%
1999	0%	0%	0%	0%
2000	8%	1%	0%	0%
2001	26%	7%	0%	0%
2002	33%	12%	0%	0%
2003	38%	15%	0%	0%
2004	38%	15%	0%	0%

Source: own calculations

The results from coal suggest that Tanzania does not have to invest any of the revenue from coal mining into substitute forms of capital. Although this might be a consequent of the very small exploitation to resources ratio (it is actually close to zero), it might also be a consequence of the crude estimates of resources and rent that were used in this study. This goes to underpin the statement we made at the beginning: if Tanzania wants to know whether its natural resources are being exploited to support the objectives of economic sustainability, then it is important to invest in institutions that can collect the data required to implement resource accounts. This study has shown is the potential benefits to be reaped from establishing such institutions.

The data for gold on the other hand suggest that the capital component for rent is positive, especially in the later years. The important policy question then becomes: does the government of Tanzania have the kind of institutions in place to not only guarantee that the right proportion of the rent is collected but that it is also invested in expanding other forms of wealth? Again, this is a

question that can only be answered with the right kind of country level data (for example, data on the amount of taxes/royalties collected from the sector and how these funds are invested).

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Appendix 1. Mineral Recoveries Tanzania Mainland 1995-2005

Mineral	Unit	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Diamond	Carat	49,538	126,670	123,090	97,830	235,000	354,338	254,271	239,761	236,582	303,920	219,639
Gold	Kg	3,200	3,180	3,230	4,270	4,890	15,060	30,088	43,320	48,018	48,176	52,236
Gemstones	Kg	111,404	142,160	509,489	48,518	95,200	150,800	96,866	195,843	1,531,547	1,613,848	1,936,618
Salt	Ton	105,000	86,700	72,511	75,000	35,893	70,000	65,000	71,200	58,978	57,062	135,410
Phosphate	Ton	6,686	717	2,120	1,431	7,250	5,100	4,000	1,182	3,738	6,570	7,096
Limestone	000 Ton	1,062	1,200	1,282	1,181	1,241	1,500	2,269	2,857	1,206	1,391	2,780
Tin Ore	Ton	3										
Gypsum	Ton	4,200	55,430	46,320	59,066	21,195	60,000	72,000	73,000	33,232	59,231	63,377
Coal	Ton	4,200	52,000	28,448	45,073	75,044	79,184	77,789	79,210	54,610	65,041	74,800
Pozolana	Ton					2,274	57,014	41,468	52,000	105,910	152,679	163,499
Kaolin	Ton	596	1,332	898								
Silver ore	Kg							6,681	7,669	7,986	13,216	12,891
Copper	Pound							5,832,158	9,309,812	8,191,035	9,348,181	7,632,959
Bauxite	Ton											1,640

Source: Economic Survey 2005

Appendix 2.1 Monetary accounts for gold, current prices

Year	Opening Stocks		Extraction		Revaluation		Closing Stocks	
	5%	10%	5%	10%	5%	10%	5%	10%
1990	209,842,033	109,920,343	9,992,758	9,992,758	0	0	199,849,274	99,927,584
1991	199,849,274	99,927,584	6,680,636	6,680,636	-72,927,897	-39,801,861	133,602,013	66,806,359
1992	133,602,013	66,806,359	2,657,661	2,657,661	-83,107,116	-42,887,412	53,152,558	26,576,608
1993	53,152,558	26,576,608	3,710,979	3,710,979	17,354,846	6,822,205	74,218,383	37,109,792
1994	74,218,383	37,109,792	4,992,535	4,992,535	20,639,425	7,823,024	99,850,343	49,925,351
1995	99,850,343	49,925,351	482,619	482,619	-90,680,590	-45,581,784	9,652,372	4,826,186
1996	9,652,372	4,826,186	446,605	446,605	-1,166,877	-806,741	8,932,100	4,466,050
1997	8,932,100	4,466,050	271,426	271,426	-3,775,004	-2,023,215	5,428,522	2,714,261
1998	5,428,522	2,714,261	471,922	471,922	3,538,004	1,533,041	9,438,448	4,719,224
1999	9,438,448	4,719,224	5,151,651	5,151,651	88,383,713	41,645,606	102,973,812	51,516,481
2000	102,973,812	51,516,481	15,729,478	15,729,478	164,758,203	88,333,785	283,461,493	155,579,743
2001	283,461,493	155,579,743	29,917,221	29,917,221	118,493,675	89,096,871	431,872,389	274,593,835
2002	431,872,389	274,593,835	41,124,619	41,124,619	63,314,287	43,233,599	536,311,296	358,952,053
2003	536,311,296	358,952,053	55,742,148	55,742,148	81,823,669	51,671,308	673,877,113	466,365,509
2004	673,877,113	466,365,509	13,692,766	13,692,766	-523,427,163	-366,062,836	164,142,716	113,995,439

Appendix 2.2 Monetary accounts for gold, five year moving average

Year	Opening Stocks		Extraction		Revaluation		Closing Stocks	
	5%	10%	5%	10%	5%	10%	5%	10%
1990	209,842,033	109,920,343	9,992,758	9,992,758	0	0	199,849,274	99,927,584
1991	199,849,274	99,927,584	8,837,763	8,837,763	-31,945,948	-20,387,721	176,741,089	88,377,626
1992	176,741,089	88,377,626	5,783,260	5,783,260	-66,860,574	-36,328,281	115,663,776	57,832,605
1993	115,663,776	57,832,605	5,350,557	5,350,557	-14,004,926	-9,677,592	107,009,407	53,505,570
1994	107,009,407	53,505,570	4,750,454	4,750,454	-16,751,124	-10,751,484	95,008,737	47,504,539
1995	95,008,737	47,504,539	445,133	445,133	-86,551,219	-43,498,347	8,902,651	4,451,325
1996	8,902,651	4,451,325	421,339	421,339	-897,201	-659,270	8,426,789	4,213,395
1997	8,426,789	4,213,395	323,153	323,153	-2,286,873	-1,305,013	6,463,070	3,231,535
1998	6,463,070	3,231,535	592,059	592,059	4,786,055	2,096,998	11,841,184	5,920,592
1999	11,841,184	5,920,592	5,976,327	5,976,327	101,640,359	47,866,325	119,457,870	59,763,244
2000	119,457,870	59,763,244	17,483,778	17,483,778	178,134,164	95,684,452	315,075,812	172,931,475
2001	315,075,812	172,931,475	32,195,966	32,195,966	117,495,613	90,381,750	464,767,391	295,509,191
2002	464,767,391	295,509,191	38,403,719	38,403,719	-2,343,420	1,290,038	500,827,690	335,202,948
2003	500,827,690	335,202,948	46,076,267	46,076,267	10,120,534	4,216,901	557,024,490	385,496,116
2004	557,024,490	385,496,116	42,652,275	42,652,275	-88,380,492	-73,058,355	511,296,273	355,090,036

Appendix 3.1 Monetary accounts for coal, current prices

Year	Opening Stocks		Extraction		Revaluation		Closing Stocks	
	5%	10%	5%	10%	5%	10%	5%	10%
1993	2,857,200	1,355,200	123,200	123,200	0	0	2,464,000	1,232,000
1994	2,464,000	1,232,000	128,000	128,000	-32,000	-80,000	2,560,000	1,280,000
1995	2,560,000	1,280,000	137,600	137,600	54,400	-41,600	2,752,000	1,376,000
1996	2,752,000	1,376,000	170,000	170,000	478,000	154,000	3,400,000	1,700,000
1997	3,400,000	1,700,000	81,000	81,000	-1,861,000	-971,000	1,620,000	810,000
1998	1,620,000	810,000	101,500	101,500	308,500	103,500	2,030,000	1,015,000
1999	2,030,000	1,015,000	112,000	112,000	98,000	-7,000	2,240,000	1,120,000
2000	2,240,000	1,120,000	93,600	93,600	-461,600	-277,600	1,872,000	936,000
2001	1,872,000	936,000	152,000	152,000	1,016,000	432,000	3,040,000	1,520,000
2002	3,040,000	1,520,000	148,000	148,000	-228,000	-188,000	2,960,000	1,480,000
2003	2,960,000	1,480,000	100,500	100,500	-1,050,500	-575,500	2,010,000	1,005,000
2004	2,010,000	1,005,000	143,500	143,500	716,500	286,500	2,870,000	1,435,000

Appendix 3.2 Monetary accounts for coal, five year moving average

Year	Opening Stocks		Extraction		Revaluation		Closing Stocks	
	5%	10%	5%	10%	5%	10%	5%	10%
1993	2,587,200	1,355,200	123,200	123,200	0	0	2,464,000	1,232,000
1994	2,464,000	1,232,000	141,000	141,000	215,000	37,000	2,820,000	1,410,000
1995	2,820,000	1,410,000	121,067	121,067	-519,733	-320,400	2,421,333	1,210,667
1996	2,421,333	1,210,667	156,000	156,000	542,667	193,333	3,120,000	1,560,000
1997	3,120,000	1,560,000	91,080	91,080	-1,389,480	-740,280	1,821,600	910,800
1998	1,821,600	910,800	141,300	141,300	863,100	360,900	2,826,000	1,413,000
1999	2,826,000	1,413,000	207,520	207,520	1,116,880	454,680	4,150,400	2,075,200
2000	4,150,400	2,075,200	171,200	171,200	-897,600	-534,400	3,424,000	1,712,000
2001	3,424,000	1,712,000	147,200	147,200	-627,200	-387,200	2,944,000	1,472,000
2002	2,944,000	1,472,000	133,600	133,600	-405,600	-269,600	2,672,000	1,336,000
2003	2,672,000	1,336,000	83,300	83,300	-1,089,300	-586,300	1,666,000	833,000
2004	1,666,000	833,000	125,720	125,720	722,680	298,480	2,514,400	1,257,200