Australian Bureau of Statistics

London Group Meeting, 2003

5-7 November, Rome, Italy

Accounting for subsoil assets in the Australian national accounts

Luisa Ryan[1], Rebecca Thomson[2] & Adam Sincock[3]

[1]Consumer Price Indexes Section
[2]National Accounts Research Section
[3]Environment and Energy Section

1. Introduction

This paper provides information on the experimental work that the Australian Bureau of Statistics (ABS) is doing to adjust the national accounts for depletions and additions of subsoil assets in the context of a satellite account. The paper begins by describing the treatment of natural resources in the Australian System of National Accounts (ASNA). The following sections discuss the conceptual framework underlying the measurement of depletions and additions, the application of the conceptual framework in calculating estimates for subsoil assets, and shows how the national accounts might be adjusted for depletions and additions to subsoil assets. Some experimental results are reported for the depletion and discoveries of subsoil assets.

2. Natural resources in the ASNA

2.1 Stocks

The national and sector balance sheets record the value of environmental assets that are defined as being within the scope of the system of national accounts - known as the asset boundary. For an asset to be included within the asset boundary of the national accounts it must have an identifiable owner, and the owner must be able to derive an economic benefit from holding or using the asset. The environmental assets in the Australian national and sector balance sheets are land, significant subsoil assets and native standing timber available for exploitation. Land valuations are available through administrative sources, and net present value techniques (which take into account current production rates, prices, costs, and discount rates) are used to value both subsoil and native forest assets. Plantation standing timber is also considered an environmental asset and plantations are included in the balance sheet as inventories because timber growth is controlled. Water and fish stocks have not been included on the Australian national balance sheet due to a lack of available data.

The balance sheet estimates the value of an asset at a point in time. In Australia, this is at the end of the financial year, June 30. The Australian national balance sheet recorded AUD $3,797 billion worth of assets as at June 30 2002, of which AUD $1,364 billion (36%) were economic environmental assets (Table 1).

Table 1. Australia's Total Assets, Current Prices, as at June 30 2002

	1994 $b	1995 $b	1996 $b	1997 $b	1998 $b	1999 $b	2000 $b	2001 $b	2002 $b
Financial	169	185	193	230	300	325	426	484	472
Buildings and structures	973	1,024	1,066	1,107	1,159	1,236	1,319	1,427	1,479
Machinery and equipment	257	265	268	274	291	301	316	322	335
Other produced	104	108	107	110	114	121	133	139	141
Other non-produced							3	6	6
Environmental	678	727	747	833	904	984	1,079	1,202	1,364
Total assets	2,180	2,309	2,382	2,554	2,767	2,968	3,277	3,580	3,797

Land accounts for 81% of the value of Australia's economic environmental assets (Table 2). The value of rural land accounts for only 12% of the total value of land. Subsoil assets account for 18% and timber (native and plantation) account for 1% of Australia's economic environmental assets.

Table 2. Australia's Environmental Assets, Current Prices, as at June 30

	1994 $b	1995 $b	1996 $b	1997 $b	1998 $b	1999 $b	2000 $b	2001 $b	2002 $b
Rural land	65	68	86	91	101	105	110	120	134
Other land	532	558	557	619	668	730	797	871	974
Oil and gas	44	55	60	67	70	72	82	101	118
Other subsoil	28	38	36	47	56	68	81	98	127
Native standing timber	2	2	2	2	2	2	3	3	3
Plantation standing timber	6	6	6	7	7	7	8	8	8
Total assets	678	727	747	833	904	984	1,079	1,202	1,364

The value of environmental assets in current prices grew strongly during the 1990's, increasing by 101% between June 30 1994 and June 30 2002. Much of this growth was due to rising prices. Environmental assets grew in volume terms by 10% during the same period (Table 3).

Table 3. Australia's Environmental Assets, Chain Volume Measures (a), as at June 30

	1994 $b	1995 $b	1996 $b	1997 $b	1998 $b	1999 $b	2000 $b	2001 $b	2002 $b
Land	912	929	903	920	928	939	944	941	954
Subsoil assets	129	154	149	162	172	175	176	183	190
Native standing timber	3	3	3	3	3	2	3	3	3
Plantation standing timber	6	6	7	7	7	8	8	8	8
Total assets	1,050	1,092	1,061	1,092	1,110	1,124	1,130	1,134	1,155

(a) Reference year for chain volume measures is 2000-2001.

3. Subsoil Assets

Subsoil assets are considered to be economic when they have a high geological assurance, extraction is expected to be profitable at the prevailing price and technology when the assessment was undertaken, and when they are owned by an economic entity (usually the government). In the Australian national accounts, economic demonstrated resources (EDR) include both proven and probable reserves. There are 27 minerals included on the Australian balance sheet, and these include coal, oil and natural gas reserves, metallic mineral reserves (e.g. copper, silver, lead) and some non-metallic mineral reserves (e.g. diamonds).

3.1 Value of subsoil assets in the Australian balance sheet

The net present value (NPV) approach is used for valuing subsoil assets in the Australian balance sheet. The resource rent is calculated using international commodity prices and costs incurred by the mining companies, including a normal return to capital. The expected life length has been calculated as the economically demonstrated stock at the end of the year divided by the five year moving average of production. The discount rate used in the Australian balance sheets is the "large business borrowing rate", as published by the Reserve Bank of Australia, converted to a real rate. This rate was chosen as it represents the opportunity cost of the mining companies funds invested in extraction.

The NPV of subsoil assets on the Australian balance sheet has been increasing, having tripled in value between 1992 and 2002 (Table 4). There have been a number of factors contributing to this trend, including falling discount rates and increasing prices for some minerals (in particular petroleum).

Table 4. NPV of subsoil assets on the Australian Balance Sheet, June 1992 and June 2002

Subsoil asset	**June 1992 ($m)**	**June 2002 ($m)**
Antimony	(*) 0	(*) 0
Bauxite	1 948	5 314
Black coal	3 282	57 15
Brown coal	169	706
Cadmium	227	10
Cobalt	25	80
Copper	2 074	10 038
Diamonds	430	(*) 0
Gold	198	2 127
Iron ore	1 417	19 416
Lead	685	(*) 0
Lithium	544	1 408
Magnesite	452	2 136
Mineral sands - ilmenite	146	2 254
Mineral sands - rutile	591	1 520
Mineral sands - zircon	1 216	2 659
Nickel	4 835	14 127
Petroleum - crude oil	13 385	26 416
Petroleum - natural gas	14 770	64 713
Petroleum - condensate	2 575	20 511
LPG Naturally occurring	1 253	6 806
Platinum group (T, PT, PD)	8	19
Rare earths (REO, Y203)	61	(*) 0
Silver	830	1 300
Tin	127	(*) 0
Uranium	2 187	4 237
Zinc	2 333	2 016
Total	55 768	245 727

(*) Indicates years where costs exceed prices. In these years the resource rent and asset value are recorded as zero.

3.2 Decomposition of change in stock valuation

The difference between the opening and closing NPVs can be decomposed into a number of changes that reflect the volume and revaluation changes that take place during the period. The changes in the parameters are described in Table 5. The changes due to discoveries and depletion are volume changes, as they result in changes to the physical stock available for extraction. Depletion results from the removal of subsoil assets from the ground, whilst discoveries reflect changes to the stock available for extraction when new finds are made or there are revisions to the stock that is economically and geologically available for extraction. The revaluation changes result from changes in the unit resource rent or the discount rate, or because the extraction rate changes. A change to the extraction rate affects the value of the stock. The faster the rate of extraction, the higher the value of the stock, as the value of extraction in future years is discounted less (SEEA, Ch 10).

Table 5. Decomposing the change in the asset valuation

NPV	Unit resource rent	Extraction rate	Stock level	Life length	Discount rate	NPV	Change
(V_t)	rr_t	E_t	$S_{t-1} - E_t + D_t$	$S_{t-1} - E_t + D_t / E_t$	r_t	$\frac{\Sigma\ rr_t * E_t}{(1+r_t)^{(St-1 - Et + Dt / Et)}}$	$(V_t - V_1)$ = discovery
(V_1)	rr_t	E_t	$S_{t-1} - E_t$	$S_{t-1} - E_t / E_t$	r_t	$\frac{\Sigma\ rr_t * E_t}{(1+r_t)^{(St-1 - Et / Et)}}$	$(V_1 - V_2)$ = depletion
(V_2)	rr_t	E_t	S_{t-1}	S_{t-1} / E_t	r_t	$\frac{\Sigma\ rr_t * E_t}{(1+r_t)^{(St-1 / Et)}}$	$(V_2 - V_3)$ = extraction rate
(V_3)	rr_t	E_{t-1}	S_{t-1}	S_{t-1} / E_{t-1}	r_t	$\frac{\Sigma\ rr_t * E_{t-1}}{(1+r_t)^{(St-1 / Et-1)}}$	$(V_3 - V_{t-1})$ = resource rent
(V_{t-1})	rr_{t-1}	E_{t-1}	S_{t-1}	S_{t-1} / E_{t-1}	r_{t-1}	$\frac{\Sigma\ rr_{t-1} * E_{t-1}}{(1+r_{t-1})^{(St-1 / Et-1)}}$	Opening stock

Source: SEEA, Ch 7.

The decomposition of the changes at the aggregate level between June 1991 and June 2002 are shown in Table 6. Revaluations account for most of the change in most of the years. The value of depletion has been increasing, whilst the value of discoveries shows an erratic pattern.

Table 6: Decomposition of changes in the NPV of subsoil assets in the National Balance Sheet, June 30 1991 to June 30 2002

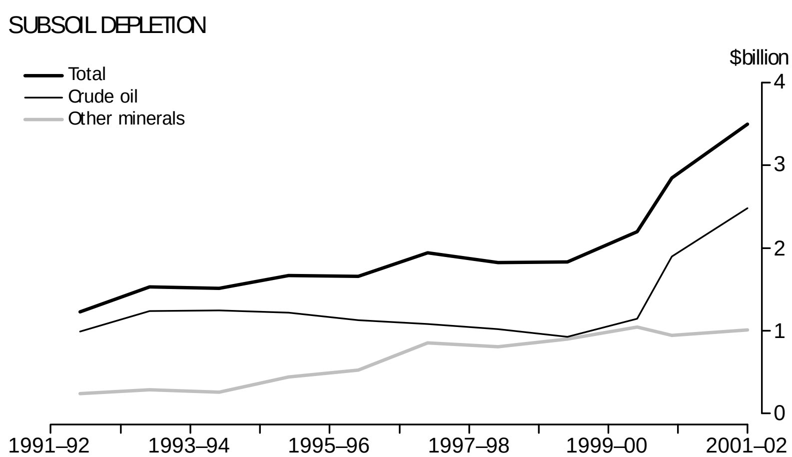
Year	Opening stock	Revaluation		Volume changes		Closing stock
		Resource rent	Extraction rate	Depletion	Discoveries	
	($m)	($m)	($m)	($m)	($m)	($m)
1991	52 020	4,957	-304	-1,126	841	56 388
1992	56 388	-1,134	1,107	-1,228	634	55 768
1993	55 768	7,571	2,015	-1,531	2,737	66 559
1994	66 559	1,147	2,546	-1,511	3,479	72 220
1995	72 220	16,214	4,988	-1,667	1,704	93459
1996	93 459	-3,614	5,810	-1,660	1,681	95 675
1997	95 675	13,796	5,873	-1,942	751	114 154
1998	114 154	5,022	6,804	-1,826	1,882	126 036
1999	126 036	5,759	6,343	-1,837	3,363	139 664
2000	139 664	16,774	5,415	-2,198	3,009	162 663
2001	162 663	29,925	7,081	-2,845	2,879	199 702
2002	199 702	37,299	8,561	-3,497	3,662	245 727

Note: The results may vary depending on the order in which the changes in the parameters are calculated (SEEA, Ch7).

3.3 Depletion estimates

The depletion in any one year is the change in the value of the asset between the beginning and end of the year arising purely from the extraction of minerals. For most minerals economic depletion is insignificant. This is particularly the case where asset lives are long or resource rents are low. As can be seen in Figure 1, the depletion of crude oil accounts for a high proportion of the total depletion estimate for Australian subsoil assets. This is a reflection of crude oil's relative scarcity and high value.

Figure 1. Subsoil Depletion



Depletion was declining until the early 1990's, reflecting a fall in crude oil resource rents due to declining crude oil prices. Depletion picked up in the mid 1990's as crude oil prices increased and discount rates fell (Table 7). Some other minerals also began to record significant levels of depletion during this period - in particular diamonds and lithium, whose asset lives began to draw to a close.

Table 7. Depletion by asset, Australia 1992-2002

	1992 $m	1993 $m	1994 $m	1995 $m	1996 $m	1997 $m	1998 $m	1999 $m	2000 $m	2001 $m	2002 $m
Antimony	-	-	-	-	-	-	-	-	-	-	-
Bauxite	0	1	1	3	3	2	2	2	1	1	1
Black coal	-	-	-	-	-	-	-	-	-	-	-
Brown coal	-	-	-	-	-	-	-	-	-	-	-
Cadmium	2	2	1	1	-	-	-	-	-	-	-
Cobalt	0	1	2	3	-	-	-	-	-	-	-
Copper	20	28	1	5	5	13	24	33	51	65	104
Diamonds	13	33	59	93	109	145	49	-	-	-	-
Gold	11	12	-	-	-	54	-	10	49	41	73
Iron ore	-	-	-	-	-	-	-	-	1	3	8
Lead	12	9	1	-	-	3	2	1	-	-	-
Lithium	65	100	133	197	295	431	520	604	647	630	554
Magnesite	-	1	-	-	-	-	-	-	-	-	-
MS - ilmenite	-	-	-	-	-	-	-	-	-	3	-
MS - rutile	-	-	-	-	-	-	-	-	-	-	-
MS - zircon	2	2	1	1	2	5	5	5	2	1	2
Nickel	6	12	6	12	7	3	4	2	1	0	0
Crude oil	988	1240	1251	1220	1132	1085	1020	932	1152	1899	2483
Natural gas	27	18	32	92	66	129	143	160	119	33	48
Condensate	7	11	13	23	25	49	47	70	135	105	144
LPG	6	5	6	10	7	10	7	7	10	6	9
Platinum	-	-	-	-	-	-	-	-	-	-	-
Rare earths	1	1									
Silver	20	5	1	1	1	0	2	3	10	18	35
Tin	2	3	-	-	-	-	-	-	-	-	-
Uranium	-	-	-	-	-	-	-	-	-	1	2
Zinc	45	49	5	6	8	10	0	8	19	38	32
Total	1,228	1,531	1,511	1,667	1,660	1,942	1,826	1,837	2,198	2,845	3,497
Total excluding crude oil	240	291	260	447	528	857	806	905	1,046	946	1,014

A number of assumptions underlie the depletion estimates. Some of the assumptions and issues are discussed in more detail in the following sections.

3.3.1 resource rent

The resource rent is calculated as the net unit price multiplied by the amount of stock extracted during the period. Where costs exceed prices, the net price and hence the economic rent will be negative, and the NPV of the asset will be set to zero in the balance sheet. Where this is the case, production will not necessarily cease in the short run, if minerals are expected to become profitable again in the future. Even though extraction may still be taking place, there cannot be any depletion in an economic sense when the asset derives no resource rent as the asset will not have any value. Although a five-year lagged moving average of prices is used in the Australian balance sheet to smooth the series, negative rents are still sometimes observed (e.g. for Nickel in 2001 and 2002).

The future resource rent is dependent on assumptions about how prices, extraction costs and extraction rates will move over the life of the asset. Given that these cannot be known with certainty it is assumed that both the future resource rent and the extraction rate remain constant. If specific information about resource rents and extraction paths were available these could be incorporated into the depletion profile.

3.3.2 depletion profile

To estimate the NPV it is necessary to estimate the rate of extraction (depletion profile) for the remaining life of the asset in any one year. This should be informed by the technical and economic characteristics of the mining industry. Four possible scenarios are described in Table 8.

Table 8. Subsoil Assets -- Technical Scenarios and Choice of "Depletion Profile"

	Technical data				**Appropriate assumption re: profile**	**Observed effects of scenario / profile**		
	Mineral stock	**Exploration**	**Future discovery**	**Production**		**Resource rent**	**Depletion**	**Income**
1.	Total stock limit is known	None or very limited	Improbable	Decline as stock levels fall	Constant pace of depletion	Falling	Constant	Falling
2.	Proven stock at any time point is limited, but there is a large inferred reserve	Continuing	Small-medium new deposits proven regular intervals	Fairly steady pace	Constant flow of resource rent	Constant	Rising	Falling
3.	Proven stock at any time point is limited, but an undiscovered stock may exist	May be continuing, but with uncertain rewards	Sporadic and uncertain	Increased / decreased so that the ratio of extraction to remaining stock is fairly steady	Geometric decline in depletion	Falling	Falling	Falling
4.	Proven stock at any time point is limited, but an undiscovered stock may exist	Intensive for short periods (when the proven stock runs low)	Large new deposits proven at long intervals	Fairly steady pace between major finds	Perhaps a constant pace of depletion between major finds (but any large find resets all the variables)	Falling	Constant between major finds, but long term rising trend	Falling

Scenario one describes a situation where the geological exploration of the nation is largely complete and the stock of subsoil assets has been comprehensively established. The constant rate of depletion suggested by this scenario should not be interpreted to imply that the physical quantities of minerals removed are necessarily stable across time - rather, it is the projected *value* of the depletion that remains constant. The depletion adjustment in each period is equal to the net present value of the mineral divided by the estimated mine life. The net present value of the owner's expected resource rents declines in each period at a constant linear pace. This is broadly analogous to straight-line depreciation assumption sometimes used in estimating the consumption of fixed capital. Scenario one is likely to apply to most of the subsoil assets in Western Europe and some small island states.

Under scenario two the nation possesses a large inferred (but not fully proven) stock of subsoil assets. Mining companies maintain a fairly steady pace of geological exploration to ensure that they have proven deposits that will support production for a given number of years in advance. Young, resource-rich nations such as Australia may be examples. This scenario suggests a constant rate of resource rent. The depletion adjustment in each period is the change in the net present value of the mineral. The ratio of production to depletion will change over time; current periods assume a lower weight in the calculations and periods a long way into the future assume a higher weight.

Scenario 3 may occur where mining companies adjust the pace of extraction periodically to maintain a fairly steady ratio between annual offtake and the remaining stock. This might apply when the nation (or company) controls a large proportion of the total world stock of a mineral. In other circumstances, it is not clear why a mining company would wish to engage in this strategy. Perhaps there could be external pressures such as contractual agreements with the owning units (typically general government). The depletion adjustment is calculated using the geometrically declining rate of extraction method. The value of depletion is equal to the net present value of the remaining future resource rents in each period multiplied by an assumed, appropriate rate of decline. The ratio of depletion to resource rents is thus constant. A consequence of this is: the faster the rate of decline in the resource rent relative to the discount rate, the larger the proportion of the resource rent attributable to depletion in the current period (Hill and Harrison (1994), p.21).

Under scenario four, as stocks run down, mining companies put intensive effort into mineral exploration. Large, lumpy discoveries of new deposits may result. In the longish intervals between discoveries, this scenario resembles one of the others (say scenario 1). The discovery of new stocks acts as a shock to the compilation system; it is unclear how depletion for the current year should be calculated because it is not known when new deposits will come to light or how large they will be.

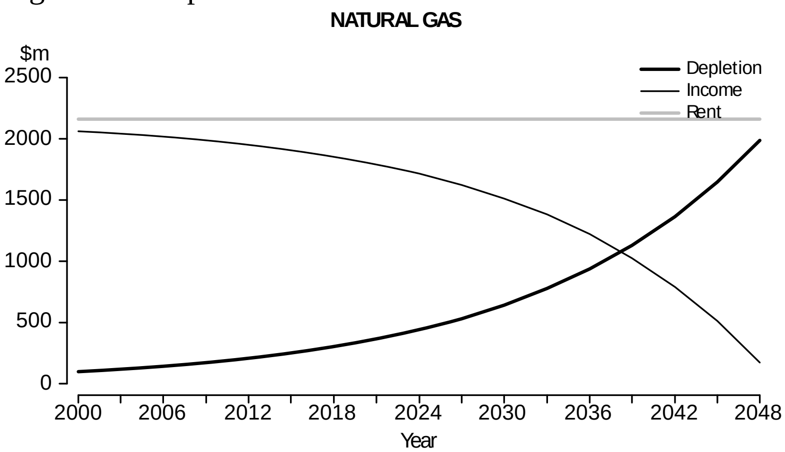
The future trajectory used in the environment satellite account is scenario two, where both the physical extraction rate and the resource rent in any one year is assumed to remain constant in constant price terms over the life of the asset. This method has the greatest intuitive appeal. The proportions of depletion and income to total resource rents will change during the life cycle of the asset - but it is the relationship between depletion and income that determines the shape of the depletion trajectory. Other countries' technical and economic circumstances may be different, and one of the other scenarios may be more appropriate for them.

3.3.3 life length

The life length of a mineral cannot be known with certainty, as it depends on production decisions, the extent to which new mineral stock is discovered and changes in technology and price. It is the expected life which is relevant at any one point in time. There are various ways of calculating the expected life length. In the National Balance Sheet, dividing the stock of the economically demonstrated resource at the end of the year by the five-year average of production derives the expected life length at the end of the period. An alternative approach suggested in SEEA is to divide the existing stock levels by the excess of expected extractions over expected renewals.

The life length has an important influence on the value for depletion. Depletion has been calculated as the difference between the NPV at the beginning and end of the period holding everything constant except the mine life, which is reduced by one year. The mine life at the beginning of the year has been derived as the available stock at the beginning of the year divided by the extraction rate in the previous period. When only depletion is accounted for, the value of the asset falls by an increasing amount in each year and depletion increases at an increasing rate as discounting assumes a time preference. Likewise, as the net income component is the difference between the resource rent and the depletion, income will fall at an increasing rate after the life of the asset (Figure 2).

Figure 2. Depletion of subsoil assets - Natural Gas



Note: These projections assume current expectations about future reserves, extraction rates, prices and discount rates for the remainder of the asset life using data at 30 June 2000.

When as asset is in plentiful supply the value of depletion in current periods is small. The bulk of the rent is considered to be income, or return to the natural resource. For instance, black coal and brown coal have asset lives of more than 169 years and 581 years respectively (Table 9), and there is no significant depletion for these minerals in the current periods. The value of depletion will increase as the physical stock of these assets becomes scarcer.

Table 9. Asset lives and depletion by subsoil asset, 30 June 1992 and 30 June 2002

Subsoil asset	Asset life June 1992 (years)	Depletion June 1992 ($m)	Asset life June 2002 (years)	Depletion June 2002 ($m)
Antimony	(*) 46	-	(*) 48	-
Bauxite	67	0	91	1
Black coal	327	0	169	0
Brown coal	948	0	581	0
Cadmium	22	2	43	0
Cobalt	(*) 24	-	1 675	0
Copper	25	20	32	104
Diamonds	14	13	5	0
Gold	12	11	17	73
Iron ore	177	0	74	8
Lead	18	12	(*) 26	-
Lithium	6	65	2	554
Magnesite	62	0	907	0
Mineral sands - ilmenite	77	0	94	0
Mineral sands - rutile	59	0	103	0
Mineral sands - zircon	45	2	79	2
Nickel	38	6	136	0
Petroleum - crude oil	9	988	8	2483
Petroleum - natural gas	59	27	71	48
Petroleum - condensate	40	7	37	144
LPG Naturally occurring	34	6	62	9
Platinum group (T, PT, PD)	200	0	370	0
Rare earths (REO, Y203)	25	1	648	
Silver	16	20	23	35
Tin	14	2	(*) 10	-
Uranium	106	-	82	2
Zinc	18	45	27	32

(*) Indicates years where costs exceed prices. In these years the resource rent and asset value are recorded as zero, and hence there is no depletion.

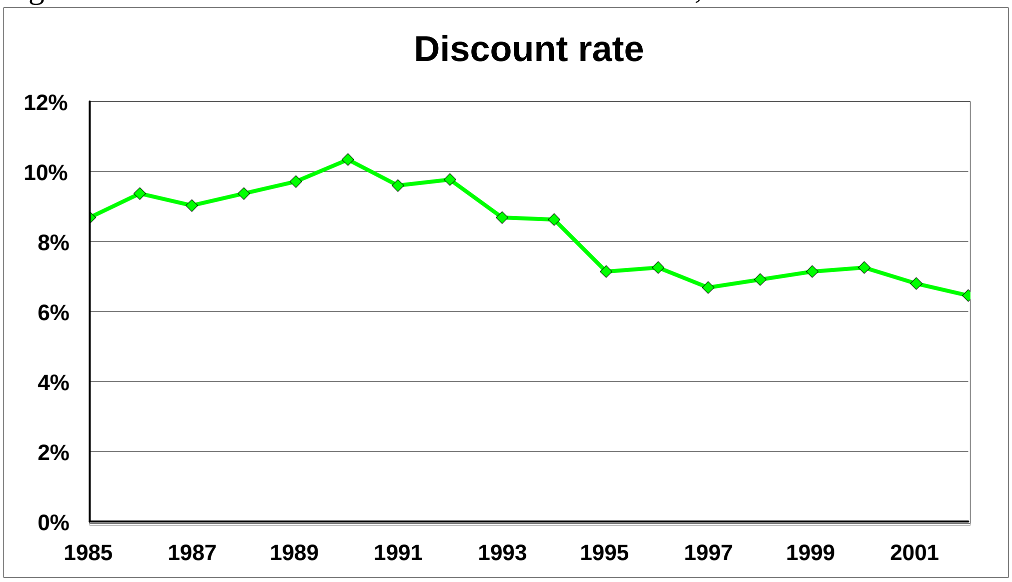
A more problematic case is where the asset life is reasonably short, but stable over a time series. An example is crude oil, where there has been an expected life length of 9 to 10 years between 1985 and 2001. Increasing the life length to take into account expected discoveries would result in a fall in the level of depletion. Given that crude oil contributes at least 50% to the subsoil depletion total, this could have a significant impact on the estimate of subsoil depletion. Where there are actual discoveries depletion will also be affected. For instance, in 1993 there was a reasonable sized discovery of copper. This almost tripled the expected asset life, resulting in depletion falling from $28 million to $1 million in this year.

3.3.4 discount rates

The discount rate reflects the owner's preference for income today rather than in the future. Higher rates of time preference translate into higher discount rates. Both asset values and depletion will be lower when higher discount rates are used. The choice of discount rate is thus important. SEEA recommends that the corporate bond rate for resource companies be used. As mining company bonds issued in Australia are limited, the large business borrowing rate has been used as the discount rate in the Australian balance sheet. Where it is not possible to use business rates, SEEA suggests that it is also acceptable to use the long-term government bond rate adjusted for a risk premium to cover uncertainty in the mining industry.

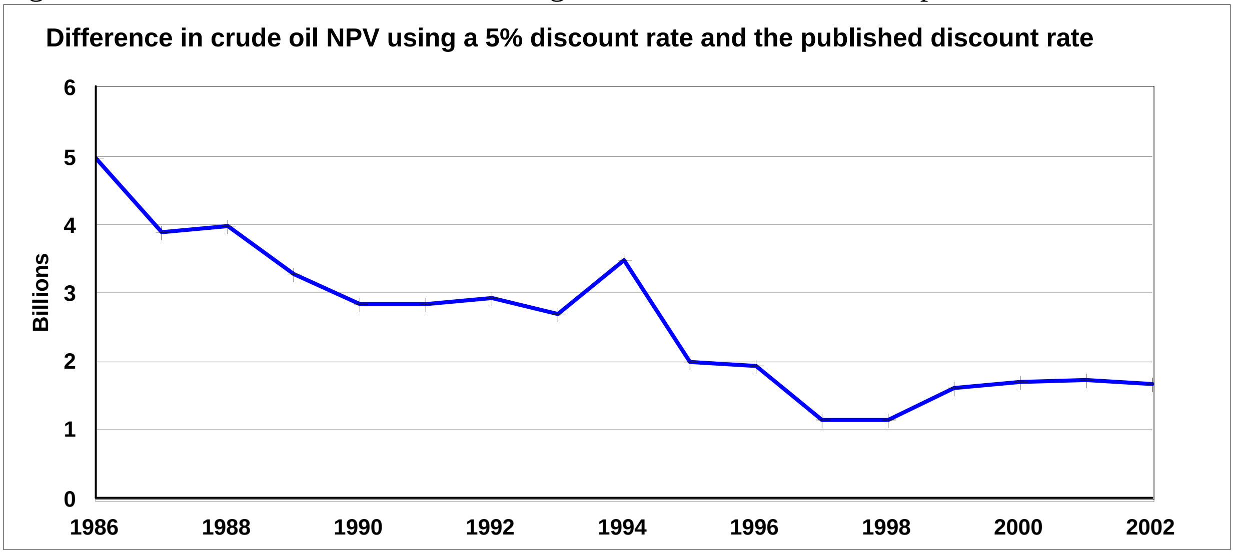
The discount rate fell from 10.4% in 1990 to 6.5% in 2001 (Figure 3). The falling discount rate has been partly responsible for the increase in the NPV of subsoil assets, which increased in value from $52 billion in 1990 to $246 billion in 2002.

Figure 3. Discount rate used in subsoil NPV estimates, 1985 - 2001



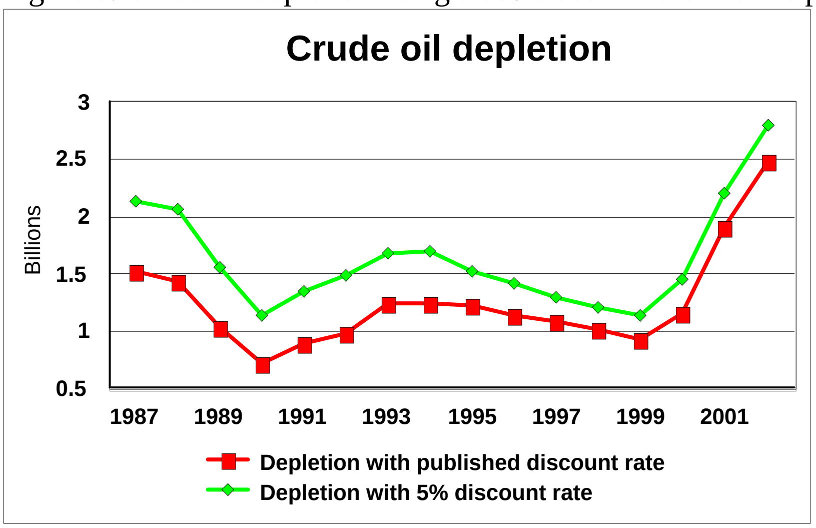
The impact of falling discount rates on the NPV and depletion can be illustrated by using crude oil as an example. The NPV of crude oil was $13.4 billion in 1991 and $26.4 billion in 2002. When a 5% discount rate is used for all years, the NPV increases to $16.3 billion in 1991 and $28 billion in 2001. As the published discount rate falls closer to 5%, the gap between the two series diminishes (Figure 4).

Figure 4. Difference in crude oil NPV using a 5% discount rate and the published discount rate



Depletion is also higher when a discount rate of 5% is used throughout the series. The gap between the published depletion estimates and depletion calculated using a 5% discount rate falls as the published discount rate falls (Figure 5).

Figure 5. Crude oil depletion using a 5% discount rate and the published discount rate

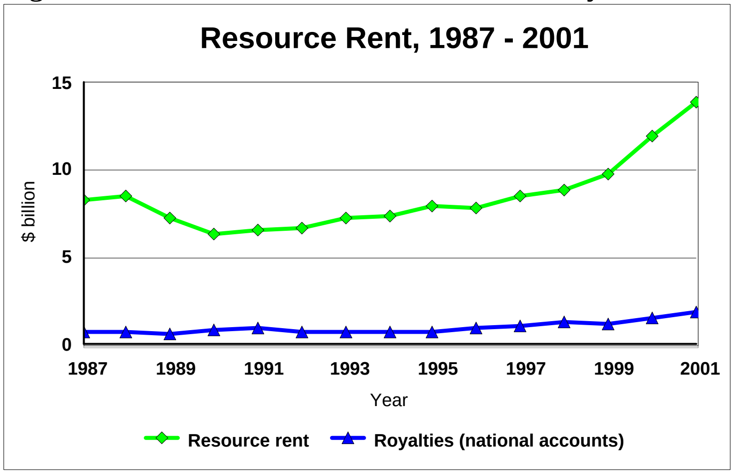


3.3.5 comparison with actual royalties

In theory, the payment that the extractor makes to the owner for the right to extract the asset should be equal to the income component of the resource rent. This payment is generally referred to as the "royalty", and in the national income accounts it is called "rent on natural assets". In many countries (including Australia) the predominant owner of natural resources is the government. Actual payments to the owner however, tend to be much lower than the resource income calculated from economic principles. Governments generally set royalty payments taking into account other priorities, such as regional or industrial development. Where this is the case the extractor is considered to have received an implicit price subsidy.

Actual royalty receipts can be compared with the experimental estimates calculated in this paper (Figure 6). In Australia, state and Commonwealth governments set royalty payments on minerals, and payments are generally based on a fixed percentage of income. In some states there are thresholds so that small companies do not pay royalties. For instance, the Northern Territory has a threshold of $50 000 for each mining company (Northern Territory Government, 2000). Special thresholds for individual minerals may also apply. For example in Queensland, bauxite attracts half the royalty rate if it is to be used within the state (Queensland Government, 1990).

Figure 6. Modeled resource rent and actual royalties, Australia 1987-2001



3.4 Discoveries

A discovery refers to where previously unknown stocks of minerals are found and delineated, or where resources in a known deposit have been extended by further exploration. Subsoil discoveries can be separated into two assets: the physical stock under the ground and the knowledge about the discoveries. In the national accounts, it is the latter that is included in income - measured as the cost of mineral exploration. It is included because it is considered to be productive activity. The value of a new discovery in itself is not considered as income because it is a gift of nature - it is included as an "other change in volume of assets" rather than as income.

While a number of national accounts experts would support the retention of this treatment even in the context of a satellite account for the environment, there are others who would contend that the output of (and income flowing from) the exploration process should relate in some way to the value of the discovery. An argument often advanced against this approach is that discoveries tend to be erratic and therefore contrary to the nature of current income. It should be noted however that income from other activities such as agriculture can also be erratic (because of changing weather conditions and product prices).

The total value of discoveries is calculated as the difference in the NPV of the subsoil asset including the discoveries, and the NPV of the subsoil asset before the new discoveries. The discovery value thus reflects the relative scarcity of the reserves. Where new discoveries add to an already large stock of an asset, the value of the discovery will be lower than when the same discovery adds to a smaller EDR.

Discoveries show an erratic pattern. In a number of years it is less than the cost of mineral exploration (Table 10). The approach that has been adopted in the environment satellite account is to include the difference between the full value of the discovery and the cost of the mineral exploration as the value of the physical discovery. The quantity of resources discovered in a period is not always directly available and for some years has to be derived as the change in stock levels between two periods plus the quantity extracted during the period. Consequently, because of reassessments of stock levels, the value of discoveries derived in this way can be negative for some minerals.

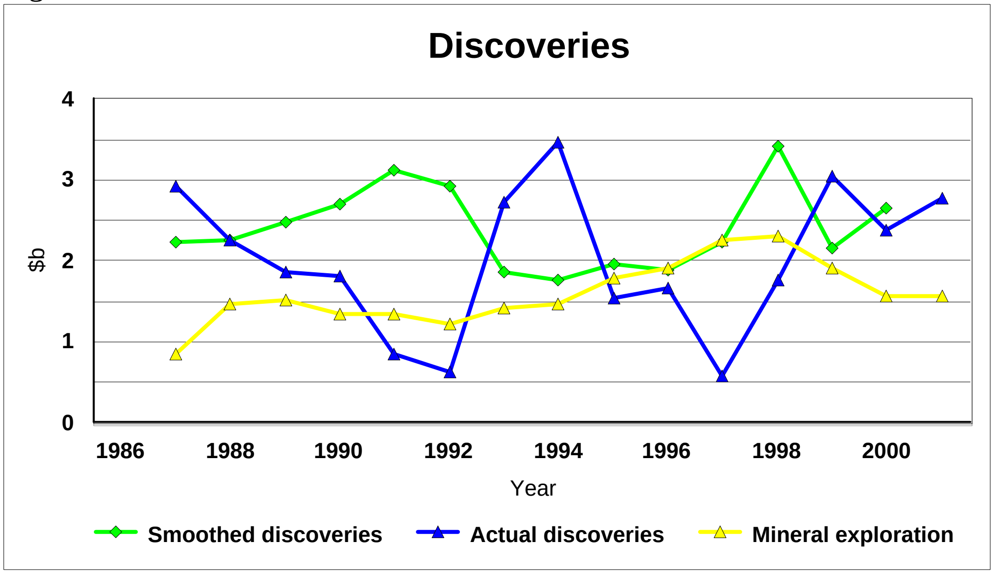
Table 10. Discoveries, Australia 1991-2002

Year	Total discovery	Cost of mineral exploration	Physical discovery – adjustment to national accounts
1991	845	1186	-341
1992	634	1075	-441
1993	2737	1244	1493
1994	3479	1301	2178
1995	1704	1582	122
1996	1681	1685	-4
1997	751	2001	-1250
1998	1882	2049	-167
1999	3363	1706	1657
2000	3009	1400	1609
2001	2879	1727	1152
2002	3662	1545	2117

There are a number of potential ways of dealing with an erratic time series. One is to include only the expected level of discoveries as income - the difference between the expectation and actual discoveries would be a capital gain / loss, and recorded in the 'other changes in volume account' as they would be considered to be non-produced. Another is to consider the discovery as accruing over the whole period of the exploration, so that the income accruing from the value of the discovery is essentially smoothed back in time.

Accruing the volume of discoveries back over the preceding five years and assuming that the new discoveries are extracted at the end of the mine life results in a smoother time series (Figure 7). Using this approach the NPV of the accrued discoveries is generally higher than the cost of the mineral exploration. If this approach was adopted the decomposition of the NPV changes would not be reconcilable (Table 6).

Figure 7. Discoveries, smoothed and actual, 1987-2001



4. Adjusting the national flow accounts for subsoil depletion and additions

Under SNA93 all resource rents arising from extraction are treated as income in the flow accounts because sub-soil assets are considered to be non-produced and implicitly assumed to be available in unlimited quantities. Accounting for depletion recognises that the return to the natural resource are comprised of depletion and income components. It would be conceptually incorrect to reduce national income by the full amount of the resource rent, except perhaps in the final years of the resource life. Subsoil assets cannot be extracted and sold instantaneously. This has two implications. Firstly, the cost to the owner of extracting some of the asset in the current period is the depletion. This will be less than the current market value of the quantities extracted because future extraction will be discounted. Hence, the owner will receive some income, except perhaps in the very final periods. Secondly, the natural assets should be treated as capital stock, not inventories. Inventories should be available for use on demand.

Using data from *Australian System of National Accounts, 2001-02* (ABS Cat. no. 5204.0), net domestic product (NDP) has been adjusted for the depletion and discoveries of subsoil assets. Depletion adjustments unambiguously lower NDP. The additions adjustment may be negative or positive. For subsoil assets it is the difference between the value of discoveries and the cost of mineral exploration (which is already recorded in the core accounts as the acquisition of an asset). The consumption of fixed capital (COFC) on mineral exploration also needs to be added back to NDP adjusted for depletion and discoveries. By replacing the intangible asset (mineral exploration) with the physical value of the discovery, depletion replaces the consumption of fixed capital on mineral exploration as the depreciation charge. The overall net change to NDP is positive is some years and negative in other years (Table 11).

The net saving levels are changed by the same amount as for NDP, but the nation's net borrowing position is left unchanged.

Table 11. Production and capital income adjusted for depletion and additions, Current Prices

	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02
	$m	$m	$m	$m	$m	$m	$m	$m	$m
+ Subsoil depletion	1,511	1,667	1,660	1,942	1,826	1,837	2,198	2,845	3,497
- Subsoil additions	3,479	1,704	1,681	751	1,882	3,363	3,009	2,879	3,662
+ Cost of mineral exploration	1,301	1,582	1,685	2,001	2,049	1,706	1,400	1,727	1,545
- COFC on mineral exploration	1,109	1147	1,199	1,248	1,316	1,364	1,448	1,509	1,543
= Net depletion adjustment	-1,776	398	465	1,944	677	-1,184	-859	184	-163
GDP	447,021	471,348	502,828	529,886	561,229	591,917	628,621	669,307	712,980
- Consumption of fixed capital	73,759	76,239	78,854	80,330	86,072	91,216	97,821	104,927	112,507
= NDP	373,262	395,109	423,974	449,556	475,157	500,701	530,800	564,380	600,473
- Net depletion adjustment	-1,776	398	465	1,944	677	-1,184	-859	184	-163
= Depletion adjusted NDP	375,038	394,711	423,509	447,612	474,480	501,885	531,659	564,196	600,636
GOS and GMI	185,849	192,149	202,687	210,158	227,762	235,465	252,924	265,261	285,564
- Consumption of fixed capital	73,759	76,239	78,854	80,330	86,072	91,216	97,821	104,927	112,507
= NOS	112,090	115,910	123,833	129,828	141,690	144,249	155,103	160,334	173,057
- Net depletion adjustment	-1,776	398	465	1,944	677	-1,184	-859	184	-163
= Depletion adjusted NOS	113,866	115,512	123,368	127,884	141,013	145,433	155,962	160,150	173,220
Net saving	9,251	6,063	10,750	19,646	20,654	18,836	23,068	20,471	23,610
- Net depletion adjustment	-1,776	398	465	1,944	677	-1,184	-859	184	-163
Depletion adjusted saving	11,027	5,665	10,285	17,702	19,977	20,020	23,927	20,287	23,773

Adjusting the national accounts for depletion and discoveries of subsoil assets will also affect growth rates, which may increase or decrease. The direction of the change in growth will depend on the growth in NDP relative to the growth in both the levels of depletion, discoveries and consumption of fixed capital on mineral exploration. For the years for which NDP has been adjusted, the largest impact on NDP growth is -0.6% in 1994-95 (Table 12).

Table 12. Production and capital incomes adjusted for depletion and additions, Australia

	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02
	%	%	%	%	%	%	%	%
GDP	5.4	6.7	5.4	5.9	5.5	6.2	6.5	6.5
NDP	5.9	7.3	6.0	5.7	5.4	6.0	6.3	6.4
Depletion adjusted NDP	5.2	7.3	5.7	6.0	5.8	5.9	6.1	6.5
Net change in NDP growth	-0.6	-0.0	-0.3	0.3	0.4	-0.1	-0.2	0.1
GOS and GMI	3.4	5.5	3.7	8.4	3.4	7.4	4.9	7.7
NOS	3.4	6.8	4.8	9.1	1.8	7.5	3.4	7.9
Depletion adjusted NOS	1.4	6.8	3.7	10.3	3.1	7.2	2.7	8.2
Net change in NOS growth	-2.0	-0.0	-1.2	1.1	1.3	-0.3	-0.7	0.2

6. Future work and further information

The work program on environmental satellite accounting is continuing. The ABS hopes to extend the depletion adjustment to include native forests. Other areas of work will be to highlight environmental protection expenditures and to look at extending the economic asset boundary to include the value of water and possibly fish. Work on the valuation of environmental damage (externalities associated with human and economic activity) is an undeveloped field of research and it is unlikely that the ABS will have the capacity to make advances in this area in the foreseeable future.

The ABS welcomes comments on environmental satellite accounts and measuring the depletion of Australia's natural resources. These can be directed to either:

David Bain
Assistant Director
National Accounts Research Section
Australian Bureau of Statistics
Locked Bag 10
BELCONNEN ACT 2616
Ph: + 61 2 6252 5829
E-mail: david.bain@abs.gov.au

Adam Sincock
Assistant Director
Environment and Energy Statistics Section
Australian Bureau of Statistics
Locked Bag 10
BELCONNEN ACT 2616
Ph: +61 2 6252 6766
E-mail: adam.sincock@abs.gov.au

References

ABS (2001), *Australian System of National Accounts , 2000-01*, (Cat. no. 5204.0)

Commission of the European Communities, International Monetary Fund, Organisation for Economic Cooperation and Development, United Nations, World Bank (1993), *System of National Accounts 1993*, Brussels / Luxemburg, New York, Paris, Washington D.C.

Hill P and Harrison A (1994), "Accounting for Subsoil Assets in the 1993 SNA" in *National Accounts and the Environment* OECD Paper at National Accounts Meeting.

Northern Territory of Australia Mineral Royalty Act (2000), www.dme.nt.gov.au/dmemain/minerals/legislation/legislation.html, Section 10. Rate of Royalty

Queensland Mineral Resources Regulation 1990, www.legislation.qld.gov.au/LEGISLTN/CURRENT/M/MineralReR90_08A_.pdf

United Nations (1993), *Integrated Environmental and Economic Accounting*, New York.

United Nations Statistical Commission (2002), *System of Integrated Environmental and Economic Accounting* (Draft SEEA - 2002). Draft report of the London Group on Environmental Accounting.