Opportunities for assessing the impact of the geosciences on the Australian economy via the system of national accounts

Background Paper prepared for

Summary

When it comes to demonstrating the economic impact of research and experimental development (R&D), the geosciences are in a very strong position compared with other research fields. This is because the R&D outcomes are monitored by a line-item in the national balance sheet. This line item covers Australia's 'sub-soil assets' of *economically demonstrated resources* awaiting future extraction. These assets were valued at $245.7 billion at the end of the 2002 financial year representing 6.5 % of Australia's total national assets and 8.4 percent of net worth.

Furthermore, there are elements of a useful chain of causality linking the annual flows of geoscience R&D spending to the value of Australia's sub-soil ass

highly deformed, and buried by a deep regolith. In order to attract 'footloose' international exploration investment, the government needs to provide an incentive that reduces this risk premium.[9]

Given that the government imposes royalties and

increases or even reducing the prices of assets such as land for which salinity and acidification problems are anticipated to reduce future streams of income. One of the most critical questions in environmental policy is whether these price impacts are an effective reflection of the risks faced by these assets.

On the 30th June 2002, Australia's overall net worth (that is to say the total assets both produced and natural, less total liabilities to the rest of the world) stood at $2,934.2bn at current prices. This was 4.1 times GDP in that year.[13] Of this, $1,362.8bn (or 46.4% of net worth and 36% of total national assets) lay in the 'non-produced' assets of land, economically viable minerals and energy reserves and native standing timber[14]. This contrasts with $335bn for machinery and equipment and $14.8bn for (breeding) livestock. The total stock of Australian land available for economic exploitation was valued at $1107.8bn (37.8% of net worth and 29% of total national assets).

The stock of minerals and energy supplies (referred to by the ABS as 'sub-soil assets') was valued at $245.7bn, or 8.4% of net worth and 6.5% of total national assets). The value of the sub-soil assets has been estimated by the ABS on the basis of their net present value (i.e. the sum of all forecasted future revenues less costs discounted by the prevailing corporate discount rate). These are forward-looking valuations that attempt to estimate what these assets are worth by using established principles of investment appraisal. Although official statisticians prefer to value assets on the basis of market prices, sub-soil assets have no direct market price. It is, therefore, necessary to use these estimation techniques.[15]

The estimated NPV of sub-soil assets is sensitive to the discount rate used to place the future stream of net revenue onto a present value basis. The NPV of sub-soil assets with several decades of profitable extraction potential is particularly sensitive to the discount rate used. This is because the value of a profit margin in the distant future is very low using commercially-based discount rates. ABS estimates of the sensitivity of sub-soil asset NPVs published for 1992 (ABS, 1992) indicate that the move from a 10 percent to a 5 percent discount rate results in a 73 percent increase in the NPV of total sub-soil assets. The current discount rate used is 6 percent, which is low by historical standards (the average rate used since 1985 is 8 percent, with a minimum of 6 and a maximum of 10 percent).

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accounting standards introduced in the 1993 update of the System of National Accounts (SNA93). SNA93 recommended that countries start to compile national and sectoral balance sheets.

[13] GDP was $712.98bn at current prices.

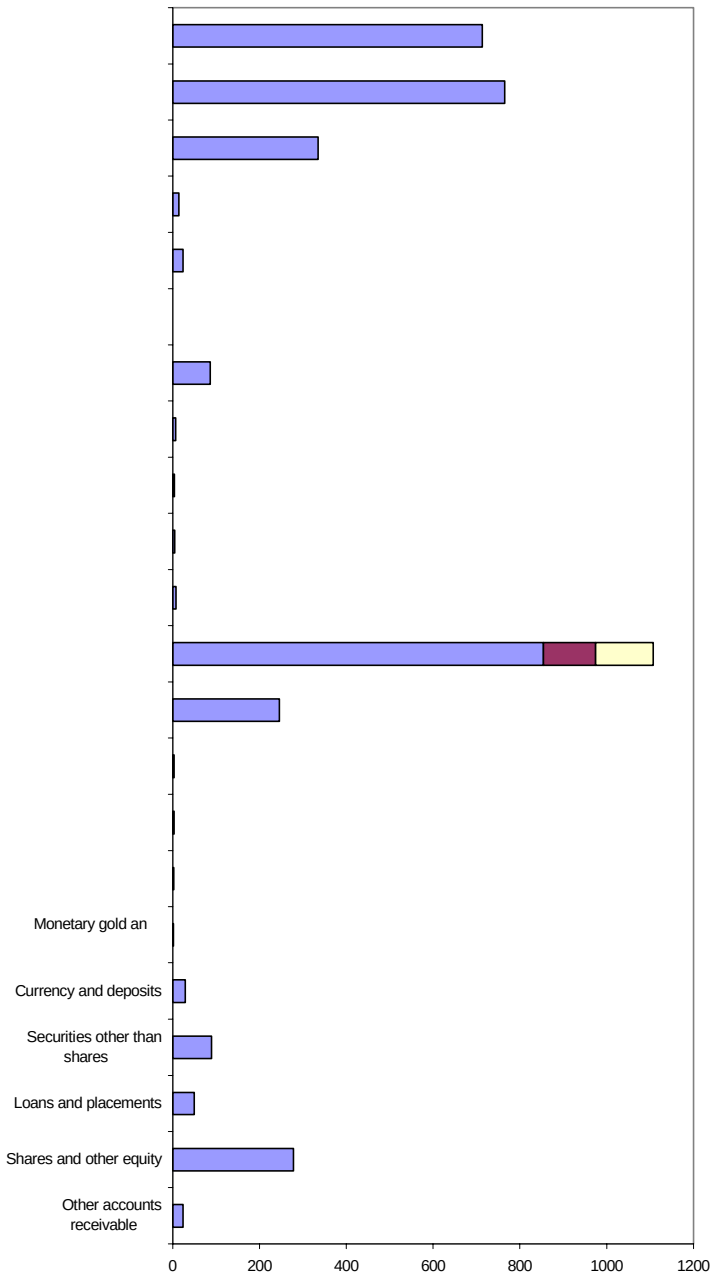
[14] ABS 5204.0 2003

[15] In theory, the net present value (NPV) of the future income stream of an asset will be the same as the market price of that asset. The use of NPV estimates by the ABS is therefore theoretically robust and a practical necessity given that there is no market price for these assets. In practice, the estimated NPV/market price of an asset may not adequately reflect the risks to the value of this asset if there is a pervasive 'institutional failure' in the process of identifying and reacting to information on these risks and/or a failure to disseminate information on these risks in a form that can be assimilated.

Table 1: Structure and Trends in Australia's National Balance Sheet 1993 to 2002

Value in
current prc017.98.98 0 0 10.98 452.0566888.a

Figure 1: Australia's National Assets in 2002



balance sheet because the eventual 'yield' on the knowledge represented by the minerals exploration capital stock is manifested in additions to the stock of sub-soil assets (ie. EDRs). To put both stocks on the national balance sheet would be a form of double counting, although there is a debate over how best to deal with the mineral exploration capital stock.[19]

Although, the mineral exploration capital stock is hidden away in the detailed tables in the national accounts, it provides a useful source of data for geoscientists.[20] This is because it provides an estimate of the accumulated investment in minerals exploration in Australia that, in turn, reflects the value of the accumulated knowledge and data-sets gained from the exploration process. Although much of the expenditure may go on field-based activity (surveying, drilling etc), this exploration activity generates new data that adds to existing datasets and allows improved analysis and pattern recognition to be carried out in the future. The larger and more comprehensive these proprietary data-sets, the greater an organisation's capability to explore effectively (i.e. knowing where to look, what to look for and how to look for it). This stock of intellectual and data resources is large, valuable and has been built up over many years by the companies that carry out exploration activity. The fact that the ABS uses a capital stock measure to track the value of this accumulated investment therefore mirrors the real scientific and technological processes involved in minerals exploration.

This capital stock aspect of minerals exploration must be born in mind when considering fluctuations and underlying trends in the real level of exploration investment by the minerals industry. In principle, the existence of these intangible assets improves the efficiency and the effectiveness of the process of minerals exploration. This means that exploration companies should be able to improve their forecasts of the investment risks faced when exploring particular geological structures via pattern recognition. This benefit from accumulated knowledge, data and sophisticated statistical analyses helps to offset the problems associated with prospecting in more difficult geological structures (allowing real levels of exploration investments to be maintained) or, alternatively, may allow real levels of exploration investment to be *reduced*.

Consequently, reductions in the underlying level of investment in minerals exploration may not necessarily be an indication of a problem. Indeed, a sustained decline in real investment spanning successive business cycles may be a consequence of the *success* in building-up the technical capacity to carry out exploration investment more effectively due to accumulated knowledge, data and

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comparisons of values to be produced.

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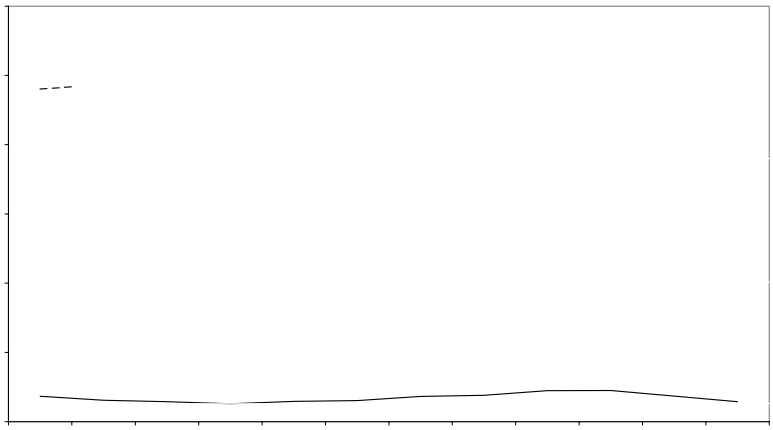
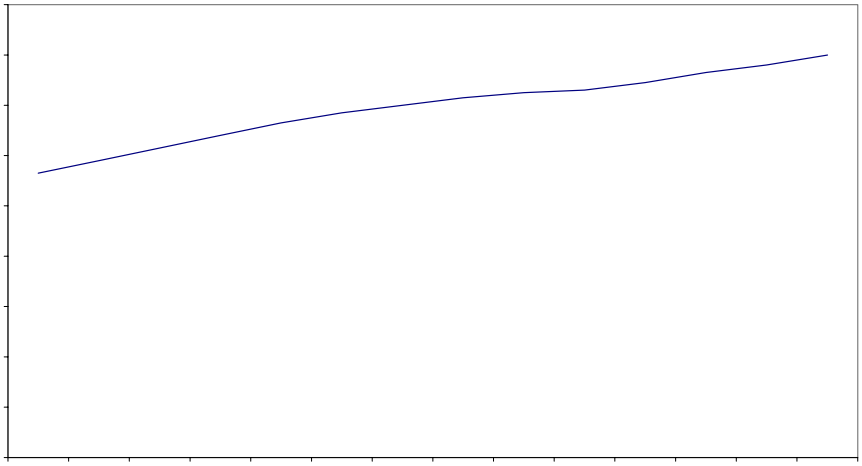
Figure 3: Behaviour of the Minerals Exploration Capital Stock



Source:

Source: from ABS 5204.0 2003



Opportunities fo

Another important aspect of the mineral exploration capital stock is that corporate reporting requirements on the outcomes from prospecting in particular areas eventually feed-back into the public domain data-sets that inform *future* exploration activity. As a result, aspects of the proprietary data become incorporated into the public domain data – to the collective benefit of the minerals industry as a whole.

No other field of research has the advantage of *both* a line-item in the national balance sheet that exists partly because of public sector R&D investment *and* an estimate of the *intangible knowledge-based asset* (the mineral exploration capital stock) that links this flow of R&D investment to the stock of assets on the national balance sheet. It is, therefore, in the interests of the community of geo-scientists that they stress the size and *nature* of the mineral exploration capital stock together with the 'feed-back' effect upon public domain data-sets when demonstrating the economic impact of their R&D on Australia. Arguably, insufficient effort has gone into communicating this message to policy-makers. Completing the links in the R&D outcome 'chain of causality' highlighted in this paper would provide a particularly compelling and robust means of communicating this message.

Geoscience a

opportunities for geoscientists lie in the fact that much work still has to be done to refine and implement environmental national accounting.

Broadly speaking, the process of adjusting conventional national accounts in order to factor in environmental factors involves estimating the impact of the depletion and degradation on the value of natural assets that have an identifiable owner who is able in principle to derive an economic benefit from that asset. Thus, natural assets (such as the atmosphere) that do not have an identifiable owner are excluded from the analysis. In Australia three classes of assets on the national balance sheet are currently treated as environmental assets. These are: land; sub-soil assets (e.g. minerals, oil and gas); and, native standing timber. Both the value of sub-soil assets and land are of relevance to capturing the impact of geosciences R&D.

The ABS has drawn upon work carried out on agricultural land values by Kemp and Connell (2001) and by the *National Land and Water Audit* in order to try to estimate the economic losses due to land degradation (increasing salinity, sodicity and acidity). Kemp and Connell used farm survey data in 2001 to estimate the difference between the capital value of farms with and without degradation. This yielded an estimate of $14.2 billion for 1999 in terms of accumulated losses due to lost future land productivity. In 2002 the *National Land and Water Audit* estimated the difference between farm profits with and without soil degradation as $2.6 billion in 1996-97 (National Land and Water Audit, 2002a). As one estimate is framed in terms of the capita

Shortages and shortcomings in data may be one factor in this. However, here are other factors such as cultural attitudes. In addition, these ABS estimates only relate to the cost of degradation to rural land, and this is only part of the story. The *National Land and Water Audit* in 2002 also estimated that the public cost of risks to infrastructure (676,400 km of roads, 5,100 km of railways, 41,300 km of streams, 2m hectares of native vegetation and urban infrastructure in 200 towns at risk) would approach $500m annually over the next 20 years (National Land and Water Audit, 2002b). The Land and Water Audit stresses that planning and implementing public works in priority areas sooner rather than later is preferable.

The current state of the official but *experimental* estimates of the economic cost of the depletion and degradation of Australia's natural resources is expressed in terms of *depletion adjusted* Net Domestic Product (NDP) (i.e. GDP less the consumption of fixed capital and the net depletion of natural capital). To date, land degradation estimates have only been prepared for agricultural land and the impact of factoring this into NDP is barely noticeable (see the estimates in Annex A). It is not clear what the impact of salinity on urban land prices will be.[27] Also, given that these adjustments are based upon the analysis of market price responses to expected future environmental degradation, the possibility exists that 'myopic' market responses to these risks mean that some types of land and other assets are currently over-valued in the face of these risks.

One reason for this may be that geoscientific and other scientific data on these risks to the future productivity of land are not connecting effectively with community and market awareness because of the manner in which the data are presented. It is plausible that the more that scientific data is translated into 'visualisable' economic variables (e.g. maps showing the contours of economic risk faced in different geographic locations) the greater the reaction of market prices for land and other assets in response to these risks.

in Depletion-adjusted Net Domestic Product it is important not to under-estimate the growing problem of degradation by only reporting the combined estimate indicated in the solid line. Changes in the value of natural capital should ideally separate-out the net depletion in sub-soil assets and the impact

sufficient only for their short to medium term production requirements. They do not seek to determine the *overall* level of economically useful resources as this would be irrationally costly relative to the commercial benefits obtained over business planning horizons. Thus, the volume and the value of sub-soil assets reflected in a national balance sheet does not reflect a finite resource, rather, it reflects economically demonstrated resources (EDRs) created by investment with a limited time-horizon in mind. Further investment and advances in scientific and technological knowledge will add to t.0659 Tw 10.98 0 0 10.91 ll 0.8 0 0 10.90 10.6062.306282 Tm(dva)Tj10.98 0 i43ÐT

Consequently, greater clarity in understanding how these factors inter-relate from the perspective of the impact of advances in knowledge upon uncertainty and risk may help to resolve this dilemma in national accounting.

Conclusions and Recommendations

Policy-makers should take note of the strong contribution of the geosciences to the Australian economy. Geosciences R&D strengthens the national balance sheet and helps to manage the risks to this balance sheet. Policy-makers should also note the unusually robust, if still incomplete, nature of the chain of causality via which the geosciences are able to demonstrate their impact on Australia's net worth. This chain of causality would be completed if geoscientists developed a formal quantification of the relationships between the level of expenditure on geoscience R&D, the level of expenditure on exploration investment and the additions to sub-soil assets generated by this knowledge. It is difficult to find any other research fields that has such potential strength for demonstrating R&D outcomes in this robust manner using the system of national accounts.

Given that the current provision of data on geological and geophysical structures already has a strong positive impact on Australia's net worth, it is worth examining whether this impact would be greater if freely available data were further improved. One way of thinking about this is to consider what we know about the balance of opportunities and risks to the national balance sheet. We know far more about the ways in which comprehensive geoscientific data strengthen the balance sheet, and eventually add to government revenue, than we do about the fragility of the national balance sheet in the face of environmental challenges. These environmental challenges may eventually increase costs and lead to fiscal pressures. The information we have on opportunities and risks relating to Australia's net worth is therefore not balanced.

Governments play *the* key role as stewards of the environment. Uncertainties over the long-term economic, social and political consequences of environmental degradation in Australia are high. At present, the extent to which policy-makers can be re-assured that markets are operating effectively in reacting to environmental risks is uncertain. Whilst some of this uncertainty can be reduced by further economic research on this issue, better and more integrated scientific data relating to landscape degradation and the economic impact of climate change would provide more favourable conditions for markets to operate effectively.

One mechanism for helping to ensure that geosciences knowledge gets translated into effective price adjustments would be to create a national geo-spatial database of risks in relation to economic asset values. The aim would be to integrate geo-spatial data on the inter-dependent risks posed by

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versus non-fractal distributions for oil) influence exploration decisions. If the theory is wrong then prospecting may overlook potential resources.

natural hazards, climate change[29] and environmental degradation with the economic data on the value of the assets similarly organised upon geo-spatial lines. Much progress has already been made to integrate data on agricultural land using a 1km resolution grid as part of the national land and water audit. A more comprehensive geo-spatial model could be used to generate contours of risks to economic assets, similar to the contours generated for hazards such as earthquake risks. The widely disseminated mapping of the co-variances and causal inter-relationships between these different risk factors and their translation into the economic dimension could play an important role in ensuring that market-prices factor-in such combined risks. The existing work on the analysis of risks in complex closely coupled systems in which human decision-making plays a causal role provides a useful input to such a project (Perrow, 1984).[30] This, in turn, would help to insure that both markets and policy-makers are able to respond earlier rather than later to these challenges.

A geo-spatial database and model of this type could be created via a collaborative program led by *Geoscience Australia*, together with the *Australian Bureau of Statistics Environment Australia*, *CSIRO*, and the *Australian Greenhouse Office*. Dedicated resources would have to be provided to these agencies to carry out such work.

The following recommendations emerge from the above discussion.

(1) Public sector geoscientists and minerals industry personnel should liase with the Australian Bureau of Statistics over the value of the minerals exploration capital stock used in the National Accounts. The aim should be to ensure that this capital stock estimate accurately reflects the underlying commercial value of the proprietary accumulations of knowledge and data used to improve the economic efficiency of the minerals exploration process. Particular attention should be paid to the rate at which this capital stock is depreciated. An industry-led working group would provide a suitable mechanism for doing this – coordinated perhaps by the Australian Minerals Industry Research Association (AMIRA International).

(2) Greater efforts are needed to understand the impact of the accumulation of knowledge, data and techniques associated with the exploration capital stock on the investment risks faced, and investment levels required, when prospecting for minerals. It would also be useful to seek to quantify the additional investment risk reduction benefits that originate from improvements to public domain data-sets made on the basis of corporate reports on exploration outcomes. These aims could be met by initiating a research project aimed at quantifying:

a. how geoscience R&D and the release of geological data-sets, in combination with other factors such as tax/royalty rates affects minerals exploration investment levels and the value of the exploration capital stock

b. how the knowledge embodied in the minerals exploration capital stock influences the productivity of the exploration and development process (as reflected in the cost of adding to sub-soil assets)

c. how the 'feed-back' from these minerals exploration outcomes in turn improves the public domain data-sets and reduces the investment risks faced in future exploration activity.

A formal investment risk-based model of these inter-relationships would provide the missing links in the chain of causality via which the geoscience community and the minerals industry are able to translate expenditure on geoscience R&D into the strength of the national balance sheet. An industry-led and financed project with participation by academic geoscientists and economists would provide a suitable mechanism for completing this chain of causality. Again, this could be led by AMIRA International.

(3) Public sector geoscientists should also establish stronger links with the Australian Bureau of Statistics over the production of 'integrated economic and environmental national accounts' in line with new interna0s7l55 (SEEAu360298 557.77872 n53139 519.79892 Tm( )

markets operate efficiently in driving adjustments to the inter-dependent challenges posed by environmental degradation, climate change and natural hazards. A publicly financed scoping study would provide the necessary assessment of the attractiveness and the feasibility of this concept.

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Annex A: Explanation of how economic growth is adjusted to take into account the net depletion and degradation of natural resources

The following account of the process of adjusting Gross Domestic Product (GDP) in order to factor-in the depletion and degradation of natural resources is based upon the article published in the ABS 2002 Year Book (ABS 1301.0 2002) and re-printed with some small changes in ABS 4617.0 2003 'Environment by numbers'. The table in the following page details the stages in these adjustments. This exposition differs from that provided by the ABS in order to make the process more understandable to someone without a detailed knowledge of the National Accounts.

The process starts with the conventional GDP measure (A), and working downwards, deducts the consumption of fixed capital (broadly equivalent to depreciation of the nation's produced fixed assets) in order to arrive at Net Domestic Product (C). The total value of subsoil depletion (the reduction in *economically demonstrated resources* due to extraction as distinct from price changes)[31] and the cost of land degradation is then calculated (G). The total value of depletion and degradation is then deduced from Net Domestic Product in order to produce an estimate of NDP taking the depletion and degradation of the nation's natural assets into account. The net gains from sub-soil asset additions are then calculated by subtracting the cost of mineral exploration from these discoveries. It is necessary to add the Consumption of Fixed Capital in minerals exploration because this figure has already been deducted in the process of producing the conventional figures – in these estimates the cost of mineral exploration provides an alternative means of handling this issue. Depletion adjusted Net Domestic Product in then calculated by adding the net contribution of mineral exploration (L) to the NDP that includes the estimate of depletion and degradation (G). Rows N and O pull-out the impact of the overall net depletion adjustment on Net Domestic Product and indicate what this adjustment looks like when the net gains from sub-soil asset discoveries are *excluded*. The final row therefore tells us what the underlying dowf0.00079 Tc 0.m(r)Tj10.9d5 Tm(t

Table A.1: Calcula

	$m (current pr	8-99	99-00	00-01
A	Gross Domes	91,5996	629,212	670,029
B	Consumption			