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# Valuation Methods of Mineral Resources

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# Issue Paper: Valuation Methods of Mineral Resources

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## Introduction

1. Moving from the physical to monetary accounts, in the case of environmental assets, require applying appropriate and consistent values to each type of asset. This allows aggregation of different types of environmental assets, integration in wider sets of accounts and comparison with non-environmental assets in terms of their contributions to the wealth of a country.

2. In the System of National Accounts (SNA), assets are valued at market prices which often are not available for environmental assets since these are rarely traded in the market. In the absence of market prices, the best available method of valuation is resorted to as proxy to market value.

3. The level of available values data and identification of benefits and uses of these assets restrict finding an appropriate value for environmental assets. Most often, available values pertain to a combination of assets which are not at the same level of detail as that in the physical accounts.

4. While benefits are the primary consideration in determining the market price of an asset, environmental assets provide benefits other than to the owners of the assets as well as qualitative benefits which are not part of the market prices.

5. SEEA 2003 recommends the use of the net present value method for valuing environmental assets where there are no direct market prices. However, questions have been raised on the application and operationalization of the net present value.

6. This issue paper is meant to provide the basis for discussing these issues towards the adoption of the net present value method in valuing environmental assets, specifically mineral assets.

## Coverage

7. For purposes of discussing the issues pertaining to the valuation of environmental assets and the recommended use of the net present value method, this paper will focus its discussion only on the valuation of natural resource stocks and changes in stock, specifically mineral stocks. It will present the different valuation methods applicable to mineral

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resources, highlighting the advantages, disadvantages and issues and limitations of each method. In the process, the other issues are also discussed/dealt with.

**Issues pertaining to the Valuation of Mineral Resources**

8. Based on a survey conducted earlier by the Sub-Soil Assets Group on subsoil accounting; the following issues were raised which centered on the use and operationalization of the net present value method, as recommended by SEEA 2003. These issues can be grouped in to the following:

a. On the Valuation of Stock of Mineral Resources
   - Calculation of the capital services on natural resources (i.e., resource rent):
     - Should taxes and subsidies be included in the calculation of the resource rent?
     - What rate of return to capital should be used?
     - How to implement the capital service approach in this context by identifying the produced and non-produced assets in production?
     - How should the resource rent be allocated to different products in case of joint production (e.g., in the case of a mine which produces silver and copper)?
     - How to deal with heterogeneity (different quality and costs) of the reserves?
     - How to deal with fluctuations in resource rents over relatively short periods of time?
     - How to deal with negative resource rents (e.g. should a moving average be recommended)?
   - Calculation of NPV? What discount rate to choose? How to calculate lifetime of the reserve?
   - How can constant price valuation of assets be obtained (e.g., using GDP deflator, constant rent from base period, etc.)?

b. On the Valuation of Changes in Stocks and, in particular, Depletion

   The following options have been put forward in the SEEA 2003. They include (SEEC 2003 Box 10.8): e

   Option E1 is consistent with the SNA. This records the value of the depletion in the other changes in assets account.

   Option E2. Partitions the actual payment into two elements. The part which corresponds to the decline in value of the asset is recorded as a capital transfer from the user to the owner as recompense for the decline in asset's value; the

rest is recorded as property income (rent) payable from the user to the owner in the distribution of primary income account.

Option E3. Maintains the recording of the actual payment from the user to the owner as property income in the distribution of primary income account but treats this as rent gross depletion. An element for the consumption of natural capital is shown in this account for the owner also to reduce the rent to a value net of depletion.

Opption E4 It is similar to option E3 but assumes that the consumption of natural capital allows for the discoveries made during the year as well as the extraction.

*Which of these options can be adopted for recording depletion in the SEEA?*

c. Other Issues

- Decommissioning costs and recording ownership of mineral related assets

  The SEEA 2003 suggested more than one option in recording decommissioning costs and recording of ownership of mineral related assets. The Canberra II group and the AEG have agreed with changing the current SNA treatment of decommissioning costs. The SEEA will have to b updated to reflect the changes in the 193 SNA Rev. 1.

- Extension of the methodology used for oil and gas accounts to other mineral resources

  Most of the methodological work as well as compilation of mineral accounts has focused on oil and gas. Would the methods for, say calculating the resource rent, valuing the stocks, etc., be applicable also for other mineral resources?

9. In line with these, is the NPV the most appropriate method in valuing resources? What about the other valuation methods?

**Mineral Resource Valuation Approaches and Methods**

10. The methods that are available and have been used/applied for valuing mineral resources stocks and flows are categorized as follows:

## A. The Market Price Approach[1]

10. Where stocks of environmental assets are tradable in the market, such as petroleum, gold, copper other and other mineral, these assets are valued by applying the prevailing prices observed in the market by the quantity of assets/goods produced or placed in stock. The SNA prefers valuing assets or goods and services at market prices. However, in the case of mineral assets, only the produced mineral resources and proven mineral reserves can be valued at direct market prices.

### *Advantages of the Market Price Method*

11. There are four advantages in using the Market Price Method, namely:

- The market price method reflects an individual's willingness to pay for costs and benefits of goods that are bought and sold in markets, such as timber, mineral or fuel wood. Thus, people's values are likely to be well defined.
- Price, quantity and cost data are relatively easy to obtain for established markets.
- The method uses observed data of actual consumer preferences.
- The method uses standard, accepted economic techniques.

### *Issues and Limitations*

- Market data is available only for a limited number of goods and services provided by the resource and do not reflect the value of all benefits/uses of the resource.
- The true economic value of goods or services may not be fully reflected in market transactions, due to market imperfections and/or policy failures.
- Seasonal variations and other effects on price must be considered.
- Usually, the market price method does not deduct the market value of other resources that are used to bring ecosystem products to market, and thus may overstate benefits

## B. The Income Approach

12. The income approach is used as a proxy measure of market value or an indirect way of using market values, where these are not present. There are five (5) methods available and tried which take into account future benefits/income streams that can be derived from the mineral assets as provider of capital services. These are:

[1]Essentials of Ecosystem Valuation. Found at: http://www.ecosystemvaluation.org/market_price.htm. Accessed date: February 12, 2007

***Net Price Method***

13. The net price method which can be an alternative to NPV is based on the Hotelling rent model which assumes that under certain market conditions non-renewable resource rent will rise at a rate equal to the rate of discount (interest rate) as the resource becomes scare. The value of the resource stock can be calculated simply as the current rent per unit of resource times the size of the stock. Because rent rises over time at a rate exactly sufficient to offset the discount rate, there is no need to discount future resource income. While this method is easy to apply, this is found to overestimate the market value of subsoil assets.

14. The Philippines applied the net price method in its initial mineral accounts series and is exploring movement to net present value method. While Canada applied both the NPV method and the net price method.

***Issues and limitations***

15. Problems on the use of this method are:

- The assumption of the Hotelling model that under perfect competition, the rents would rise in line with the rate of interest may not hold in reality due to market imperfection.
- The rent used may include other forms of rent, e.g. rent due to the differences in the cost of production, monopoly rents due to the exercise of market power in setting price, in addition to the true resource rent
- The world prices of minerals are not governed by perfect competition.

***El Serafy Method or User Cost Method***

16. This method is applied to environemntal assets that generate marketed services. It makes a distinction between the "true income" and the "gross receipts" generated by an asset. It defines true income as the amount of income that would be sustained indefinitely regardless of the actual finite lifetime of the asset by suitably investing a portion of the gross receipts generated which can be the depeletion cost, otherwise referrred to as the user cost. In terms of formula, the relationship between true income and gross receipts is:

$$N - X = N/(1+i)\, n + 1$$

where $X$ is the true income that can be consumed, $N$ is the total annual receipts (net of extraction cost), $i$ the rate of discount and $n$ the further number of years for which current extraction rates could be sustained.[2]

[2] M. del Mar Rubio Varas, 2005. "Value and Depreciation of Mineral Resources Over the Very Long Run: An Empirical Contrast of Different Methods," Economics Working Papers 867, Department of Economics and Business, Universitat Pompeu Fabra. Found at: http://www.econ.upf.edu/docs/papers/downloads/867.pdf. Accessed date: February 22, 2007.

***Issues and Limitations***

17. In order to calculate the user costs, several assumptions are needed that are likely to bias the estimates. Regarding *Nt,* the current level of receipts is held constant during the lifetime of the resource. The rate of extraction is also held constant until the final exhaustion of the resource, thus the life expectancy of the reserve in the present year, *n*, is not allowed to change over time. It also assumes a constant discount rate.

***Net Present Value (NPV)***

18. The SNA and SEEA recommend the use of NPV for valuing mineral resource stocks and changes in stocks. Based on the survey conducted by the sub-soil assets group, almost all countries adopted the NPV method except for the Philippines.

19. Net present value (NPV) is a standard method that predicts the net income flows of an asset over its entire economic life.. It entails forecasting the stream of future net revenues a mineral resource would generate if exploited optimally, and then discounting this revenue stream using an appropriate cost of capital. Under certain conditions -such as no taxes - the sum of the discounted revenue values from each time period will equal the market value of the resource.

20. **Advantages.** NPV has four key elements to evaluate an asset/investment:

**Time Value of Money.** NPV recognizes the concept that a dollar earned today is worth more than a dollar earned five years from now.

**Income Flows.** NPV calculates a resource's expected income flows and includes the unique risks of these. Using NPV helps to eliminate accounting inconsistencies, since the income flows encompasses all the benefits not just the profits.

**Risks.** NPV incorporates the risks associated with a resource via the expected income flows and/or discount rate.

**Flexibility.** NPV provides flexibility and depth, since the NPV equation can adjust for inflation and be used with other analytical tools such as Scenario analysis.

21. NPV is consistent with maximizing the value of a firm and is used by investors in the evaluation of a company or in capital budgeting decisions when comparing the value of different projects.

***Issues and Limitations:***

22. Despite its many benefits, however, NPV has some limitations of which valuators need to be aware of.

***Income Flows and Discount Rate***

23. An NPV analysis has two main inputs: income flow and cost of capital. Income f\low represents the forecasted Net Benefits during the lifetime of the resource. In most real-life

situations, determining this is not easy, considering the number of assumptions and expectations underlying the actual income flow.

24. Choosing an appropriate discount rate is crucial to the NPV calculation. There are several ways to approximate the discount rate but the most common is to look for an investment of equivalent risk whose discount rate is known.

25. A basic approach in selecting an appropriate discount rate, is to consider the rate of return which the capital needed for the project can yield if invested in an alternative venture. Obviously, NPV value obtained using variable discount rates within the lifetime of the resource is more realistic than that calculated using constant discount rate for the entire life of the resoruce.

26. For some professional investors, their investment funds are committed to target a specified rate of return. In such cases, that rate of return can be applied as the discount rate for the NPV calculation. In this way, a direct comparison can be made between the profitability of the project and the desired rate of return.

27. The interest rate used to discount future income flows to their present values is a key input of this process. Most firms have a well-defined policy regarding their capital structure. So the weighted average cost of capital (after tax) is appropriate for use in all projects. Alternately, higher discount rates can be used for more risky projects. Another method is to apply higher discount rates to income flows occurring further along the time span, to reflect the yield curve premium for long-term debt.

***Availability of Capital***

28. It is assumed that a positive NPV will be adopted regardless of the capital required. Capital is assumed to be readily available, no matter how much is needed or what are the constraints. This is rarely the case because access to capital markets is limited according to the overall performance of the company. Therefore, large NPVs may be foregone, given the capital requirements.

***Option Investments***

29. The capital requirements may change over time, requiring decisions along the way that may change the risk profile. NPV uses information known at the time of the completion of the analysis. It is calculated in a static manner that does not allow for any future changes. The rigidity of this assumption will lead to underestimation of values.

***Reinvestment rate***

30. There are assumptions made about what rate of return is realized on cash that is freed-up before the end of the project. In the NPV model it is assumed to be reinvested at the discount rate used. This is appropriate in the absence of capital rationing. In the IRR model, no assumption is made about the reinvestment rate of free cash, which tends to exaggerate the

calculated values. Some people believe that if the firm's reinvestment rate is higher than the Weighted Average Cost of Capital, it becomes, in effect, an opportunity cost and should be used as the discount rate.

### *NPV variations of the US Bureau of Economic Analysis: Current Rent Methods I and II3*

31. The Bureau of Economic Analysis (BEA) in valuing minerals stock and changes – depletion, additions, and revaluations - in the stocks, used the following two methods. These methods rely on three variables: (1) The normal return to invested capital, based on some average rate of return of investments prevailing in the economy; (2) the return to capital based on the market value of the capital stock in the oil industry; and (3) the per-unit capital cost of additions to the stock of proved reserves.

32. These two methods assume that over time the rent per unit will increase with the rate of interest; thus, the current per-unit rent is used to value resource and depletion.

33. Current Rent Method I, utilizes an estimate of a normal or average rate of return to investment to estimate the rent to the associated capital invested in the mining industry and then derives the resource rent as a residual. This method applies this average, economy wide rate of return to investment to an estimate of the replacement cost, or market value, of the net stock of associated capital invested in mining and then adds depreciation to estimate a "normal" rent to invested capital. The rate of return used is 6 percent, approximately the 45-year average real rate of return to investment in corporate bonds and equities for the period ending in 1991, which is an estimate of the rate of return available on alternative investments. The steps in estimating the rent to and value of the resource are as follows:

1. Gross rent is calculated as total revenue less current operating expenditures. (Current operating expenditures are those associated with bringing the mineral from the deposit to the wellhead or mine gate.)
2. The resource rent is obtained by subtracting the rent to capital (both depreciation and a normal rate of return for capital) from the gross rent.
3. The per-unit rent to the resource equals the resource rent divided by the physical quantity extracted.
4. The value of the resource equals the per unit rent times the physical quantity of reserves

34. Additions and depletion are valued at rent per unit times the physical quantities of added and extracted reserves.

[3] Carson, Carol S. Accounting for Mineral Resources: Issues and BEA's (Bureau of Economic Analysis) Initial Estimates. Survey of Current Business. April 1, 1994

35. Revaluations--the effect of price changes - are computed as a residual: The value of the resource at the end of the current year less its value at the end of the preceding year, plus depletion during the year, less additions during the year.

36. The advantage of this method is that it is relatively straightforward and requires few assumptions. The main disadvantage is that an explicit assumption must be made regarding the appropriate rate of return. In addition to the conceptual and empirical problems in identifying an appropriate rate, pre-specification of a rate does not allow for relatively low or high rates of return in the mining industry due to conditions specific to the industry.

37. On the other hand, the Current Rent Method II, derives resource rent by removing the market value of capital, both physical and capitalized expenditures, from the value of the resource reserve. The steps to deriving the per-unit rent are as follows:

1. Gross rent per unit is derived by dividing gross rent by the physical quantity of extraction.
2. The total value of the mineral reserve (the resource and the associated invested capital) equals the gross rent per unit times the quantity of reserves.
3. The value of the resource equals the total value of reserves less the current replacement value of the net stock of invested capital.
4. Resource rent per unit equals the value of the resource divided by the quantity of reserves.

38. The advantage of this method is that it does not require an explicit assumption about the return to invested capital associated with the resource.

***Appropriation Method***

39. In many countries, governments are the primary owners of the nation's natural resources. As landowners, governments collects the entire rent derived from extraction of the resources they own. Resource rent is normally collected by governments through fees, taxes and royalties levied on companies that carry out extraction. One way of estimating the economic rent attributable to a resource is to equate this with the fees, taxes and royalties collected from the companies involved in the resource extraction. However, in practice, fees, taxes and royalties tend to understate resource rent as they may be set by governments with other priorities in mind; for instance, implicit price subsidies to extractors, and encouraging employment in the industry. Also, the rate of payments to government may not move in line with market prices for the extracted product though one would expect the true economic rent to do so. When these data are not separately identifiable, or suitable, resource rent must be imputed using various indirect methods. However, if the two sets of data are available, publishing a comparison of the values may be useful for economic policy analysis. (SEEA 2003)

## C. The Cost Approach

40. The cost approach provides an alternative way of valuing mineral assets. This is used to value depletion which considers the cost needed to replaced a certain mineral assets. This approach is measured based on how much asset plus or minus a discount or premium as the case may be e.g. replacement cost less accrued depreciation.

### The Appraised Value Method[4]

41. The Appraised Value Method is based on the premise that the real value of an exploration property or a marginal development property lies in its potential for the existence and discovery of an economic mineral deposit. The Appraised Value Method assumes that the amount of exploration expenditure justified on a property is related to its value. The cost approach is given some validity by the fact that option agreements on mineral properties are often based on expenditures required to earn an interest.

42. The basic tenet of the appraised value method is that an exploration property is worth the meaningful past exploration expenditures plus warranted future cost. . An important element of this method, which is often overlooked in its application, is that only those past expenditures which are considered reasonable and productive are retained as value. Productive means that the results of the work give sufficient encouragement to warrant further work by identifying potential for the existence and discovery of an economic mineral deposit. Warranted future costs comprise a reasonable exploration budget to test the identified potential, which can be geophysical or geochemical anomalies, or promising showings or mineralized zones already identified. As noted previously, if exploration work downgrades potential, it is not productive and its cost should not be retained as value or should be reduced. Obviously, if the property is considered to have negligible exploration potential, it has little or no value.

43. Past expenditures are usually analyzed on an annual basis. In times of high inflation, past expenditures are escalated to the effective date of valuation or current unit costs are applied to the work retained. Usually little of the expenditures more than five or so years prior to the effective valuation date are retained.

44. In the case of dual or multiple property ownership, the Appraised Value of the whole property is determined first. Then the value is apportioned to one or more of the property owners. During an option or earn-in period, the property interests of each party are assumed to be the final earned interests. Some properties carry a royalty, commonly as a net smelter return or net profits interest. Such royalties are deducted as a pro rata percentage from the Appraised Value apportioned to the non-royalty holder. This is done to recognize the

[4] Roscoe, William E. Valuation of Mineral Exploration Properties Using the Cost Approach. Found at: http://www.cim.org/mes/pdf/VALDAYBill_Roscoe.pdf. Accessed Date: February 28, 2007.

existence of the royalty and is not meant to imply a value for the royalty. In some cases it may be necessary to differentiate between a net smelter return and net profits interest royalty by using a higher percentage for the former relative to the latter.

45. The derivation of an appraised value by adding the retained past expenditures to the warranted future costs should be thought of as an abstract exercise to determine the cost of an exploration 'play' on a property, which is considered to be the Appraised Value. It should not be thought of in terms of who pays for the future exploration program, although it is similar to the earn-in aspect of some option agreements. It should also not be thought of as an accounting exercise where exploration expenditures are booked and can be written off over time or against income.

***Issues and Limitations***

46. The appraised value Method is best applied to properties which are actively being explored. It is more difficult to apply the method to properties that have been idle for some years, especially those which have had substantial expenditures in the past. The key to the valuation of inactive properties is a realistic assessment of the remaining exploration potential, which could be in the form of untested targets, potential to increase the grade or tonnage of the existing resource, or potential for development with changes in technology or economic conditions.

47. The Appraised Value may have to be adjusted to Fair Market Value if the local market for properties is markedly depressed or markedly high as of the effective date of the valuation. These conditions can be recognized by applying a subjective market factor, usually in increments of 25%, as either a discount or a premium to the Appraised Value. A premium may be applied to the Appraised Value to recognize an advantageous location such as proximity and geological similarity to an operating mine or new discovery.

48. One advantage of the Appraised Value Method is that exploration cost information and technical data are readily available for most exploration properties and marginal development properties. It is a good way of comparing the relative values of exploration properties. The main disadvantage is that experienced judgment is required to separate the past expenditures considered to be productive from those considered not to contribute to the value of the property, and to assess what is a reasonable future exploration program and cost. This leaves the method open to misuse and possible abuse.

***Question: With the various valuation methods presented, what should be the best valuation method for mineral resource?***

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