B Methodology and data

B.1 Introduction

Estimates of multifactor productivity for eight mining sub-industries presented in this report are generated using an updated version of a model developed by Gretton and Fisher (1997). The model is based on the neoclassical growth model formulated by Swan (1956) and Solow (1956), and is concerned with tracing out the growth in output relative to the growth in inputs to production, thereby identifying productivity improvements associated with the use of those inputs.

This appendix contains a brief description of the model used to estimate multifactor productivity, and a description of the data and data sources.

B.2 The basic model

A standard approach to studying the productivity of labour and capital in production begins with an aggregate production function of the form:

$$Y = Af(K, L) \tag{B1}$$

where Y is output measured in terms of value added and K and L are measures of capital and labour inputs, f is a constant returns to scale function of factor inputs K and L that defines the level of output in year t, given the conditions and technology in the base period, and A is a productivity shift term reflecting influences such as technical change, unmeasured changes in the quality of labour and capital and the intensity with which capital and labour are used.

For any industry, (B1) can be written in percentage changes as:

$$y = a + s_k k + (1 - s_k) l \tag{B2}$$

where y, a, k and l are the percentage changes in Y, A, K, and L, respectively, and s_k is the elasticity of Y with respect to K. Assuming:

- constant returns to scale (since s_k plus (1-s_k) sum to one); and

- capital and labour are paid according to their marginal products, s_k is the capital share in the value of output.

Multifactor productivity (MFP) is equivalent to 'a' in equation B2, and is therefore defined to be:

$$MFP = y - s_k k - (1 - s_k) l$$

Additional technical details about the growth model and its application to the estimation of capital inputs can be found in Gretton and Fisher (1997, appendixes C and D).

B.3 Data sources

As noted by Gretton and Fisher (1997), the information necessary to undertake an analysis of productivity growth in the various sub-divisions or classes within the mining industry is not available from a single source, although much of the required data are available from Australian Bureau of Statistics publications 8415.0 and 8414.0. Another important source of the data used to prepare the productivity estimates reported in this study is the Australian Bureau of Agricultural and Resource Economics (ABARE), particularly their annual compendium of statistics – *Australian Commodity Statistics*.

A difference between the earlier analysis of productivity in key industries within the mining industry conducted by the Productivity Commission is that estimates are only reported for eight sub-divisions or classes within the mining industry rather than nine. Changes to the ABS survey reporting mean that separate productivity estimates are no longer available for 'Bauxite mining' (ANZIC class 1312). In this study, the category 'Other metal ore mining' now incorporates the bauxite mining sector.

As with the earlier study, there are a number of industry classifications within the mining industry as a whole that are not covered in this study. The most important of these in terms of output shares is 'Services to mining', which generally accounts for around 6 per cent of mining industry value added. Services to mining differs from the other mining classes in that a significant component of output is exploration and exploration support activities, as opposed to mining per se. The other sectors that are not considered in this study are 'Construction materials', which includes sand and gravel mining, and 'Mining nec', which includes salt mining and non-metallic mineral mining. Collectively the latter two sectors account for around 3 per cent of mining value added.

The key variables and parameters used in the construction of the MFP series for each subdivision or class are as follows:

Gross output at current prices by mining industry is measured as the value of sales plus increase in stocks of finished goods plus other operating revenue of mining industry production units (or establishments). Gross output is net of the indirect taxes that are included in measures valued at market prices, and is generally preferred to market price measures for productivity studies. The components of gross output at current prices by mining industry were obtained from ABS mining industry statistics (see ABS Cat. nos. 8414.0 and 8415.0).

Gross output at average 1989-90 prices for each mining industry was provided by the ABS for the years 1985-86 to 1994-95. For 1984-85 and earlier, gross output at 1989-90 reference prices was derived by deflating current price data using industry specific implicit output-price (current-period weighted) deflator information referenced to 1989-90 and provided by the ABS. For 1995-96 to 2006-07, gross output at constant prices was derived by deflating current price estimates using an implicit price deflator obtained by dividing current price gross output by the quantity of output, where quantity of output was equal to measured commodity production for each mining industry, as sourced from ABARE (*Australian Commodity Statistics* — various issues). For industries comprising multiple sub-industries (for example, the oil and gas sector), the quantity of output was estimated using a divisia index of the individual outputs with weights based on gross value of production shares.

Purchases of material and services at current prices by mining industry were estimated from cost information obtained from the annual mining industry census plus business expenses (including land tax, rates and payroll tax, travelling expenses, accounting and legal expenses, insurance premiums, advertising and bank charges) derived from industry of enterprise statistics (see ABS Cat. nos. 8414.0 and 8415.0). Information on business expenses was available for the years 1990-91 to 1994-95 for the industries black coal mining, oil and gas extraction and metallic mineral mining. The series were completed by allocating the relevant data across establishment industries and across years on the basis of relative wages and salaries.

Purchases of materials and services at average 1989-90 prices were obtained from the ABS for the years 1985-86 to 1994-95. For 1984-85 and earlier years, purchases at 1989-90 reference prices were derived using implicit input-price deflator information provided by the ABS. Separate price information was available for the input categories: purchases of materials, electricity and fuels, and other goods for resale; charges for processing or other commission work, and payments to mining contractors; outward freight and cartage and motor vehicle running expenses; rent, leasing and hiring expenses, and changes in stocks of materials and other supplies.

Business expenses information was deflated using the implicit price deflator for gross domestic product. For the period from 1995-96 to 2006-07, purchases at 1989-90 reference prices were obtained by deflating current price estimates using an index of mining input prices published by the ABS (Cat. no. 6427.0, Table 21 Coal mining: materials used).

Value added (at current prices) was estimated directly as the difference between gross output at current prices and purchases of materials and services at current prices.

Value added (at constant prices) was calculated directly as the difference between gross output at constant prices and purchases of materials and services at constant prices.

Employment is used as the measure of labour inputs in the current study.[1] It is measured as the number of working proprietors and employees on the payroll, including those working at separately located administrative offices and ancillary units at 30 June. The number of persons employed was obtained from the ABS census of mining (see ABS Cat. nos. 8414.0 and 8415.0).

Capital capacity is estimated using a generalised perpetual inventory method (PIM). The detailed estimation method (ie the generalised logistical method) is described in Gretton and Fisher (1997, Appendix C). The method uses annual expenditure on machinery and equipment (including motor vehicles and other plant and machinery) and non-dwelling construction (including buildings, other structures and mine development) by industry, and obtained on an annual basis from ABS Cat. nos. 8414.0 and 8415.0). For more details regarding the PIM and the specific assumptions used regarding asset lives and the asset retirement function see Productivity Commission (1999).

Indexes of capital-good prices for machinery and equipment and non-dwelling construction were used to convert current price investment to constant 1989–90 prices, and were obtained from ABS Cat. no. 5206.0, National Income, Expenditure and Product (as extracted from the ABS dX data base system, August, 2008).

Separate measures of capital capacity of equipment and construction were estimated. These estimates were weighted together to form a composite measure of capital capacity for each industry using average relative rental prices, where the rental price is defined, without time or industry subscripts, as:

[1] Labour inputs for productivity studies are conventionally measured by the number of hours worked by persons employed in each industry. For individual mining industries, hours worked information is not available.

$$p = q(r + \delta) - \dot{q} \quad \text{(B5)}$$

where p is the rental price of capital, q is the expected price of a unit of capital, r is the nominal rate of return, δ is the rate of depreciation and $\dot{q}$ is the expected change in the price of the capital good over the period. In this framework, the expected rental price of a unit of capital for production in a period is equal to the depreciation in the value of the asset over the period due to its use in production, returns to management net of depreciation, less any revaluation of the nominal value of the asset due to inflation or other price changes.

The expected value is first approximated by reference to actual flows in any one year (that is, the ex post rental price). To avoid negative average relative rental price weights due to large annual fluctuations in the fortunes of mining industries, the rental price values were averaged over the period 1968-69 to 2006-07. This longer term averaging in turn, avoids measuring capital as a negative input to production when period-specific rental prices are negative.

Labour and capital input shares by mining industry are used to weight labour and capital inputs together for the calculation of multifactor productivity. The individual shares are estimated by dividing the relevant current price series by the level of value added at current prices. The cost of labour was estimated as wages and salaries from the industry census plus superannuation and workers compensation payments by industry of enterprise. Information on superannuation payments was available for the years 1990-91 to 1994-95 for the industries black coal mining, oil and gas extraction and metallic mineral mining. The series were completed by allocating the relevant data across establishment industries and across years on the basis of relative wages and salaries. Payments to capital including depreciation (ie gross operating surplus) were estimated by deducting payments to labour from value added at current prices.