

**Estimates of industry level multifactor productivity in
Australia: Measurement initiatives and issues**

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1. Introduction

1. The ABS has been producing productivity estimates for approximately 20 years. Considerable development work took place during the 1980s leading to the publication of the first estimates of multi-factor productivity (MFP) in 1985. Since then MFP estimates for the market sector have been produced each year and released in conjunction with the annual national accounts.

2. Over recent years, interest in productivity has increased significantly with particular interest in the productivity performance of individual industries and the performance of the Australian economy relative to other countries. In response to this increased demand, the ABS commenced a project in 2002 aimed at developing industry level estimates of MFP. Estimates were released in a research paper in 2005 (Zheng, 2005) and confirmed that while there were some limitations in the available data, meaningful estimates could be developed.

3. Following on from that positive finding, the ABS was funded to develop and release annual industry level MFP estimates. A small team has been established to complete this work and investigate a range of other productivity related topics. Other areas in the ABS are also undertaking analysis and compilation associated with productivity.

4. This paper discusses the current state of work on the measurement of multifactor productivity (MFP) at the industry level for Australia. To a large extent the work has uncovered additional questions and issues and as a result this paper is not conclusive but hopefully can stimulate discussion towards better solutions. It is noted that the estimates presented still in the early stage of development, and as such they are experimental, not official.

5. As part of the process of estimating industry MFP a reference group was established to assist the ABS in this work. The reference group comprises individuals from government, private enterprise, industry bodies and academia who are both interested in, and experts in, productivity measurement. Part of the work presented here has been presented to the reference group, whose members have been instrumental in taking the ABS's productivity work forward.

6. The paper discusses the following:

- the methodology and the results of industry MFP estimates for Australia.
- the issues in creating data series for capital and labour.
- the issues in aggregating industry level MFP based on value added.
- the issues of interpretation of industry MFP. One aspect is the need to look at the underlying reasons behind the measured trends in each industry. A case study of the Mining industry is presented as an example.

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- future directions in measuring industry level MFP that the ABS is undertaking.

2. Industry MFP

7. The ABS has compiled MFP indexes for 12 separate market sector industries. The market sector industries as defined by the ABS are:

- Agriculture, forestry & fishing,
- Mining,
- Manufacturing,
- Electricity, gas & water,
- Construction,
- Wholesale trade,
- Retail trade,
- Accommodation, cafes & restaurants,
- Transport & storage,
- Communication services,
- Finance & insurance, and
- Cultural & recreational services

2.1 Methodology

8. The ABS uses a value added approach to measure industry MFP. That is, for MFP, the changes are measured as the growth in the rates of real value added to the combination of two factor inputs, capital and labour. The industry value added index is a Laspeyres index, which is used because it is consistent with aggregate market sector output and GDP. The industry capital services index is a Tornqvist index based on weighted changes in productive capital stock that are formed from the perpetual inventory method. The labour input is based on data from the Labour Force Survey (LFS), which is a household survey providing hours worked by industry. The aggregate labour and capital indexes are combined using their respective income shares to form an aggregate input index using a Tornqvist methodology. The calculation of MFP is output divided by the combined capital labour input index.

2.2 Forming MFP growth cycle estimates by industry

9. Data are available from 1984-85 to 2004-05. Tables 1 and 2 present annual average growth rates of value added MFP for the market sector industries, and Figure 1 presents the entire MFP series for each industry.

10. Table 1 shows the average annual growth rates of MFP by industry where the years selected correspond to the productivity growth cycles of the market sector. These growth cycles are constructed by forming a long-term trend using an 11-term Henderson moving average with the difference between the original series and the long-term trend used to detect peaks. When comparing average growth rates between peaks, it is important to compare peaks that are assumed to have similar levels of capacity utilisation.

Table 1: Annual average growth in MFP for the market sector industries, market sector productivity growth cycle (Experimental estimates)
Per cent per year

	1984-85 to 1988-89	1988-89 to 1993-94	1993-94 to 1998-99	1998-99 to 2003-04	1984-85 to 2003-04
Agriculture, forestry & fishing	-1.3	3.9	3.8	3.8	2.4
Mining	2.8	2.4	0.2	-0.5	1.1
Manufacturing	1.7	1.8	0.7	2.2	1.4
Electricity, gas & water	5.1	4.1	2.2	-2.6	1.9
Construction	-1.2	-0.2	2.7	0.9	0.5
Wholesale trade	0.5	-2.4	5.5	1.9	1.5
Retail trade	-2.8	0.9	1.8	1.3	0.4
Accommodation, cafes & restaurants	-1.8	-1.5	1.6	0.8	-0.1
Transport & storage	1.4	1.3	2.1	2.6	2.0
Communication services	4.7	5.6	3.9	-1.0	3.2
Finance & insurance	2.4	1.4	2.3	-0.3	1.2
Cultural & recreational services	-3.7	-0.8	-1.6	1.3	-1.1
Market sector	0.7	0.9	2.1	1.0	1.2

11. One important issue that arises here is that the industries will not necessarily have the same cycles as the market sector, or the same as each other. When constructing trend MFP estimates for the individual industries using an 11 term Henderson moving average the results showed that not one industry had all of the same peaks as the aggregate for the market sector. However, most industries had at least one peak that was the same as the market sector.

12. Table 2 presents industry MFP growth over five year cycles from 1984-85 to 2004-05. The estimates show a mixed story in comparison with table 1. This highlights that the growth rates for particular industries are sensitive to the choice of years. While there are minimal differences at the aggregate market sector level, different pictures emerge for a number of industries depending on the choice of year to measure the average growth rate. That is, the choice of start and end year used to determine the growth cycle period affects the growth rate. Agriculture, forestry & fishing and Wholesale trade show two contrasting results, with growth in opposite directions for similar periods in some instances. Another example where a different picture emerges is for Manufacturing, which shows a relatively constant, albeit slower, growth rate in table 2 over the different periods. This is a different story from table 1, which shows that the Manufacturing industry had a slowdown in MFP growth over the second half of the 1990s.

Table 2: Annual average growth in MFP for the market sector industries, five year cycles (Experimental estimates)
Per cent per year

	1984-85 to 1989-90	1989-90 to 1994-95	1994-95 to 1999-00	1999-00 to 2004-05	1984-85 to 2004-05
Agriculture, forestry & fishing	0.4	-1.1	8.3	1.7	2.2
Mining	3.3	2.4	0.5	-2.0	1.0
Manufacturing	1.5	1.2	1.3	1.2	1.3
Electricity, gas & water	5.7	3.2	1.4	-3.0	1.8
Construction	-1.6	0.3	2.6	0.7	0.5
Wholesale trade	-0.5	0.9	3.1	2.2	1.4
Retail trade	-2.3	0.5	2.3	0.9	0.4
Accommodation, cafes & restaurants	-1.7	-0.8	0.7	1.2	-0.1
Transport & storage	0.9	2.1	2.2	2.4	1.9
Communication services	5.1	4.5	2.5	0.2	3.1
Finance & insurance	2.1	2.0	2.0	-1.5	1.2
Cultural & recreational services	-4.0	-0.8	-0.5	1.3	-1.0
Market sector	0.7	1.0	2.0	0.6	1.1

13. Figure 1 presents the annual MFP indexes for all the market sector industries. This figure further highlights the disparities in movements and peaks across industries and the difficulty in determining similar productivity cycles.

14. The next phase of the ABS's research is to analyse in detail the plausibility of the results for each industry. This will involve examining the data series that form the MFP estimates for each industry. For instance, investigations will involve looking at the quality of the current output and sales data, the quality of the output deflators used to get volume estimates. The ABS will also examine the intermediate input structures, the quality of the labour input series, the quality of the capital data, and the quality of the income shares. The following sections highlight the key investigations that have been undertaken to date in understanding the industry MFP estimates.

Figure 1: MFP for the market sector industries (Experimental estimates)
Index 2003-04=100

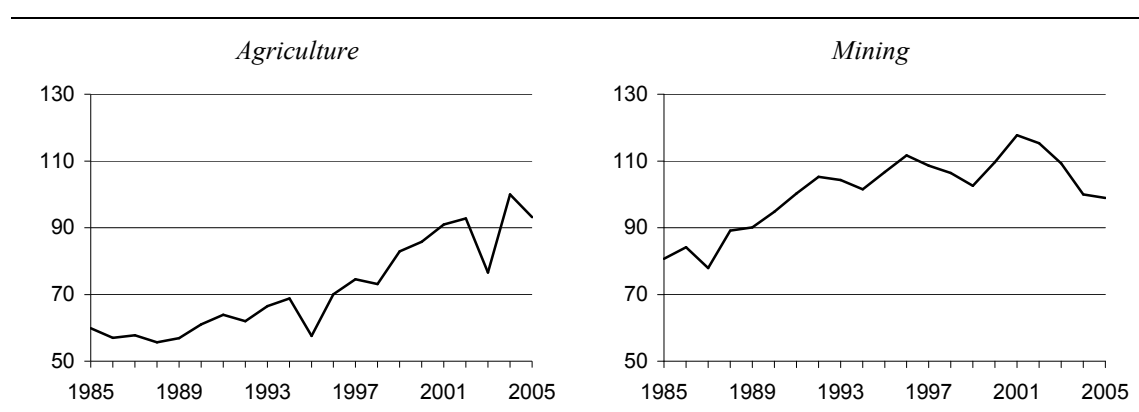


Figure 1: Continued

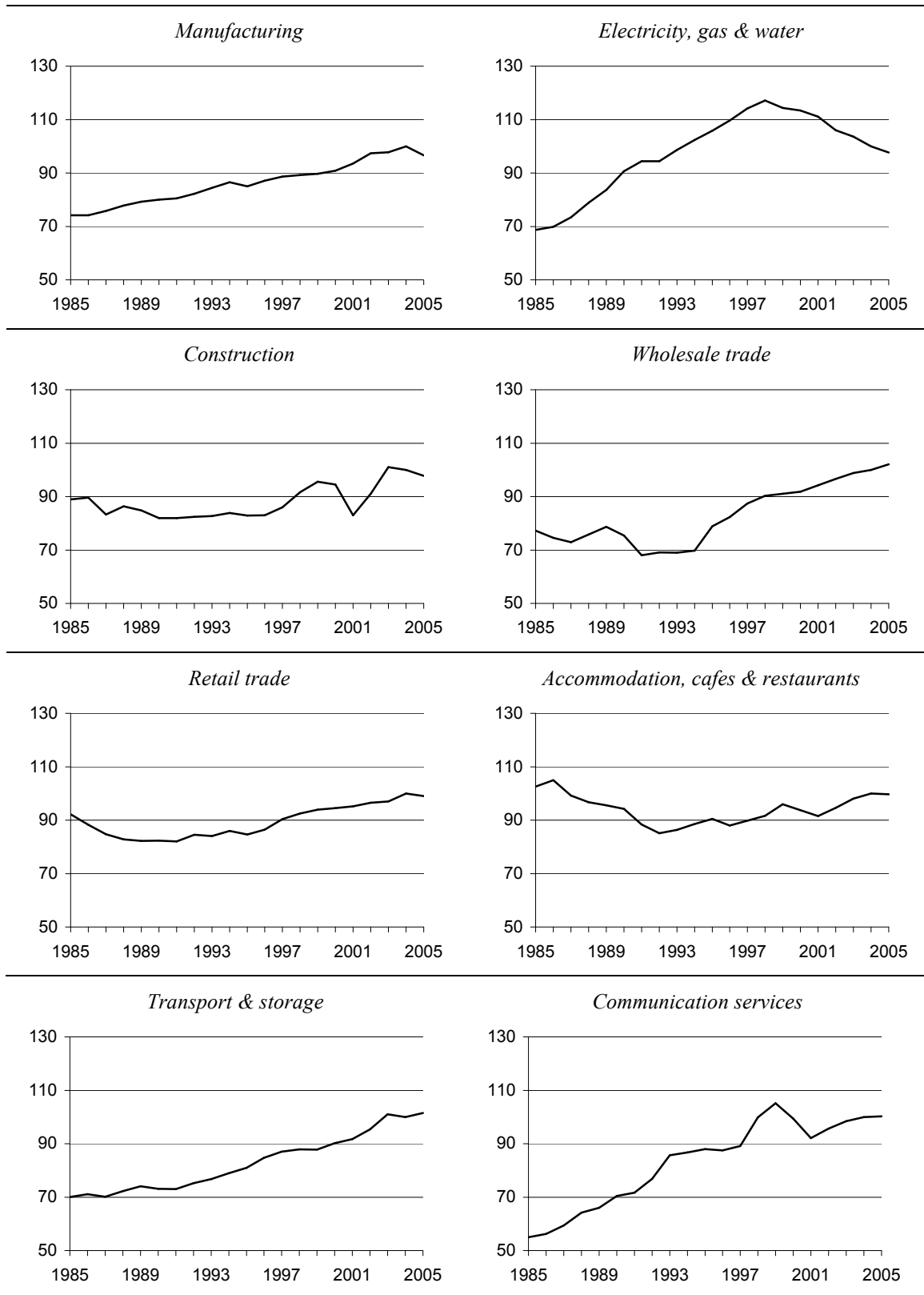
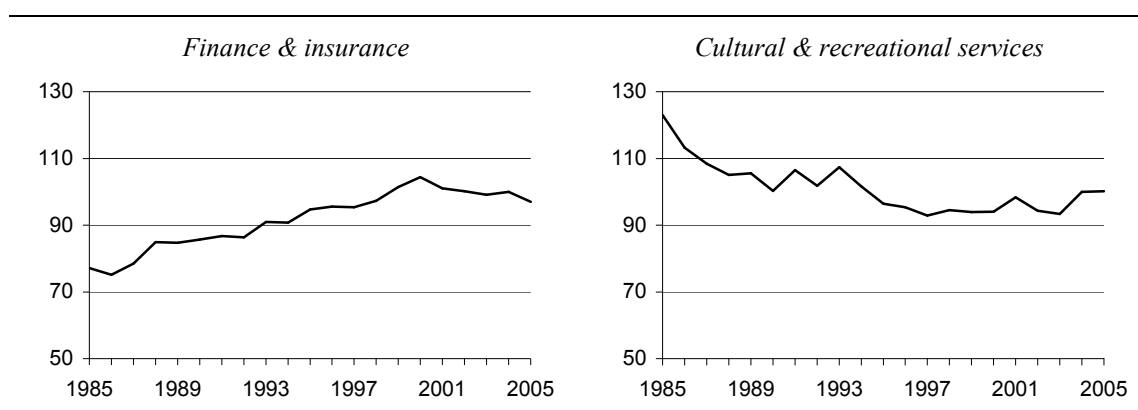


Figure 1: Continued



3. Measuring capital inputs

15. Currently the ABS produces industry level capital services indexes and these capital services indexes are used as the capital input for industry level and market sector MFP estimates. The following section describes the issues involved with creating capital services indexes and the implications for industry level MFP estimates. More specifically, the focus is on the user cost of capital equation and the sensitivity of capital services indexes to changes in the rate of return component of the equation. The ABS currently uses a combination of endogenous and exogenous rates of return in the user cost of capital equation.

16. Capital services are a flow measure based on the productive capacity of capital. The capital services produced by an asset over its life are not usually observed, however, they may be approximated by assuming that capital services are directly proportional to the productive capital value of the asset. This relationship is fixed over the asset's life, but does vary between asset types and even between different vintages of the same asset, since it depends on the expected life of the asset, the discount rate and the rate of decline in the asset's efficiency. Aggregate capital services indexes are created by aggregating different vintages of the same type of asset, and then aggregating different assets using rental prices as weights to form an aggregate index.

17. These rental prices are analogous with user costs as they represent the price of capital. This is a significant issue in compiling the aggregate index of capital services. Given that rental prices are not observable for all assets, they must be estimated in another manner. The user cost of capital equation is the method used by the ABS to calculate rental prices.

18. The user cost of capital equation in its most basic form is comprised of three components: depreciation of the asset, a rate of return reflecting financing costs, and a capital gain/loss component. The ABS also includes a corporate income tax component, tax depreciation allowances, investment credits and indirect taxes. The user cost equation is as follows:

$$UC_{ijt} = T_{ijt}(r_u \cdot p_{ijt} + d_{ijt} \cdot p_{ijt} - p_{ijt} + p_{ijt(t-1)}) + p_{ijt} \cdot x_{it}, \text{ where}$$

- i = industry
- j = asset type
- t = discrete time period
- T = income tax parameter
- r = rate of return
- p = price deflator for new capital goods
- d = depreciation rate
- x = effective average non-income tax rate on production

19. The primary focus of ABS's work to date has been on the calculation of the rate of return, r , and its implications for capital services calculations and corresponding industry level MFP estimates.

3.1 Rates of Return

20. Rates of return may be calculated in one of two ways. Firstly, we can use an endogenous rate of return which is represented by the internal rate of return for the industry. Using an endogenous rate of return to calculate user costs of capital imposes some implicit assumptions, namely that the underlying production function exhibits constant returns to scale, that markets are competitive, and that the expected return is the same as the realised return. Also, using an endogenous rate of return imposes the same rate of return for all asset types within an industry. The endogenous rate of return is derived using the Hall and Jorgenson (1967) approach, which equates the capital income to its cost for a particular asset, where the total capital income equals all non-labour income. A practical issue involved in using an endogenous rate of return is that when capital income is small, the associated internal rate of return will be small.

21. An alternative approach to calculating rates of return is to use an exogenous rate of return such as the interest rate on government bonds. Using an exogenous rate may lead to a difference between the calculated capital rent, defined as the rental prices multiplied by the productive capital stock, and capital income, defined in the national accounts as gross operating surplus (GOS). This difference may be attributed to returns to other assets such as intangibles that would be included in the GOS used to derive endogenous rates of return but these assets are not in the productive capital stock on which the capital rent is calculated. As well, GOS is an ex-post measure of the return to capital. To the extent that expected and realised returns differ, inconsistencies in average rates of return will exist.

22. Currently the ABS uses a combination of endogenous and exogenous rates of return when creating MFP estimates. To help overcome the problem of a negative user cost, the ABS applies a floor to the rate of return of 4 percent plus the consumer price index (CPI) rate. If the endogenous rate is greater than or equal to this floor then the endogenous rate is used in the user cost equation. However, if the derived endogenous rate is less than the set exogenous rate of 4 percent plus the CPI rate, then the exogenous rate is used. Using this approach no adjustment is made when the endogenous rate is greater than the exogenous rate.

23. Tables 3 and 4 show the average rates of return by industry for the three approaches and the deviations from the average exogenous rate of return of the other

two approaches. The tables are split into two periods covering roughly the last 40 years, where table 3 is from 1964-65 to 1984-85 and table 4 is from 1984-85 to 2004-05

Tables 3: Average rates of return and deviations from the exogenous rate of return, by market sector industry, 1964-65 to 1984-85
Per cent

	<i>Average rates of return</i>			<i>Deviations from exogenous rate of return</i>	
	<i>Exogenous</i>	<i>Endogenous</i>	<i>Current</i>	<i>Endogenous</i>	<i>Current</i>
Agriculture, forestry & fishing	11.78	7.12	13.29	-4.66	1.51
Mining	11.78	14.99	15.26	3.21	3.48
Manufacturing	11.78	14.00	15.19	2.22	3.41
Electricity, gas & water	11.78	7.28	11.78	-4.50	0.00
Construction	11.78	11.81	13.10	0.03	1.32
Wholesale trade	11.78	11.00	12.43	-0.78	0.66
Retail trade	11.78	10.65	12.23	-1.13	0.45
Accommodation, cafes & restaurants	11.78	7.72	11.78	-4.06	0.00
Transport & storage	11.78	5.97	11.78	-5.81	0.00
Communication services	11.78	11.47	12.79	-0.31	1.01
Finance & insurance	11.78	14.99	16.46	3.21	4.68
Cultural & recreational services	11.78	8.90	11.78	-2.88	0.00

Table 4: Average rates of return and deviations from the exogenous rate of return, by market sector industry, 1984-85 to 2004-05
Per cent

	<i>Average rates of return</i>			<i>Deviations from exogenous rate of return</i>	
	<i>Exogenous</i>	<i>Endogenous</i>	<i>Current</i>	<i>Endogenous</i>	<i>Current</i>
Agriculture, forestry & fishing	7.99	1.30	8.39	-6.69	0.40
Mining	7.99	6.42	8.38	-1.58	0.39
Manufacturing	7.99	6.86	8.55	-1.13	0.56
Electricity, gas & water	7.99	3.77	7.99	-4.22	0.00
Construction	7.99	9.63	11.34	1.63	3.35
Wholesale trade	7.99	5.78	8.13	-2.21	0.14
Retail trade	7.99	6.85	8.43	-1.14	0.44
Accommodation, cafes & restaurants	7.99	3.41	8.01	-4.59	0.01
Transport & storage	7.99	1.11	7.99	-6.89	0.00
Communication services	7.99	8.13	8.94	0.14	0.95
Finance & insurance	7.99	8.31	10.50	0.32	2.50
Cultural & recreational services	7.99	1.76	7.99	-6.23	0.00

24. The tables show that the average return for each approach can differ substantially for each industry. Most variation occurs between the exogenous rate of return and the endogenous rate of return, as shown by large deviations of the endogenous rate of return from the exogenous rate of return. Also, the average endogenous rate of return is, for the majority of industries, less than the average

exogenous rate or return. By definition, the current approach used by the ABS produces average rates of return that are higher than the exogenous rate of return, however, for the majority of industries, the deviations from the exogenous rate of return are not significantly large.

25. Another key component of the user cost equation is the choice of price deflator. Currently, the ABS uses specific asset deflators in estimating rental prices but in some cases this has led to negative rental prices for particular assets and in extreme cases in the aggregate. To avoid this issue the current practice is to set any negative rental price to a very small positive number (0.001). By adjusting the negative rental prices in this way the capital stock weights return to ‘reasonable’ levels and the weights of the remaining assets are also adjusted. As a consequence, the corresponding capital services index also returns to a ‘reasonable’ level. However, the question remains as to how to appropriately deal with negative rental prices.

26. One alternative approach that might overcome the negative rental prices is to recognise that the user cost equation is an expectations model. However, the ABS’s current approach is that the variables are measured *ex poste* rather than *ex ante*. Shifting to an *ex ante* approach and assuming that businesses base their general inflationary expectations on movements in the CPI, then the CPI would be the price deflator (p_{ijt}) in the user cost of capital equation above. For a complete *ex ante* model the rate of return should be an exogenous rate.

27. Given the possible combinations of rates of return and price deflators we have tested the following combinations – the results of which are shown in Figure 2

- Current ABS approach (as defined above);
- Exogenous rate of return with separate asset price deflators;
- Exogenous rate of return with the CPI as the price deflator;
- Endogenous rate of return with separate asset price deflators; and
- Endogenous rate of return with the CPI as the price deflator.

Figure 2: Capital services for the market sector industries, 1964-65 to 2004-05
Index 2003-04=100

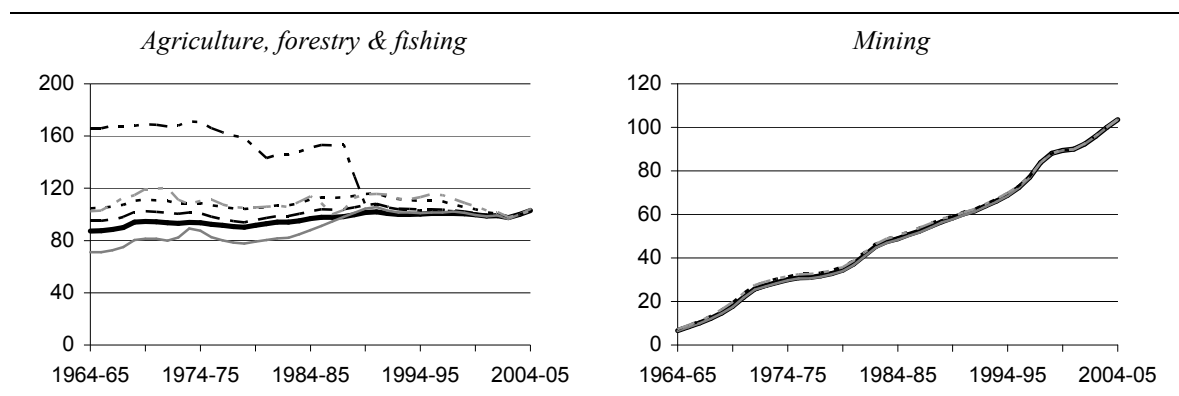


Figure 2: Continued

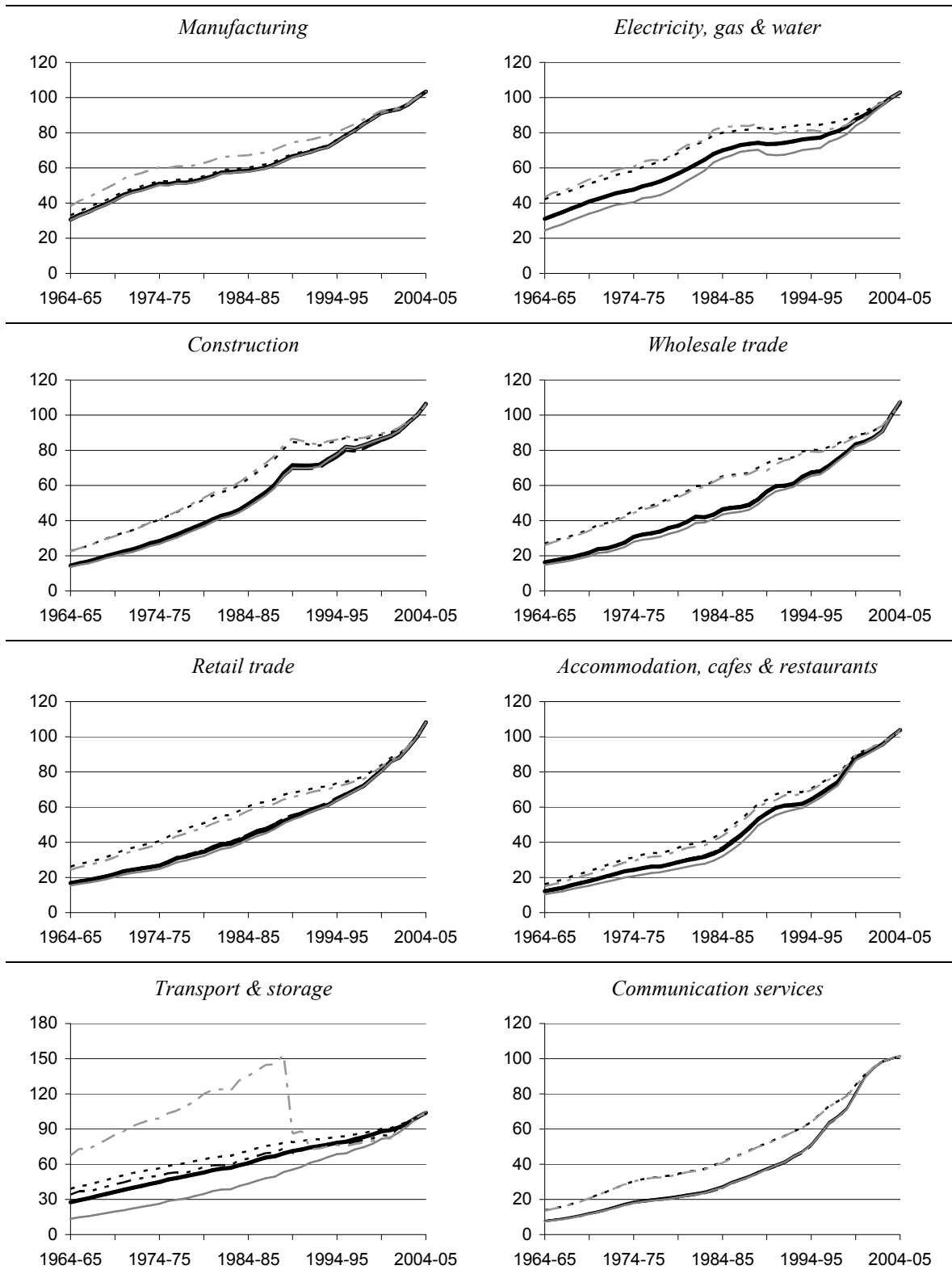
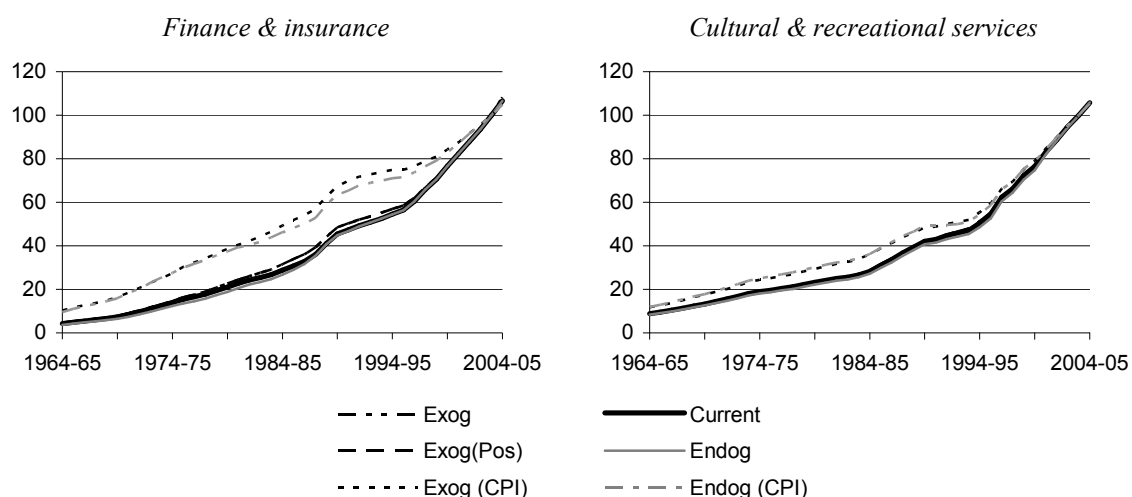


Figure 2: Continued



28. The data show that for Mining and to a lesser degree Manufacturing that the choice of approach has little effect on the capital services index. With the exception of Agriculture, forestry & fishing and Transport & storage, the rest of the industries also show little difference other than when the CPI price deflator is used. For Agriculture, forestry & fishing and Transport & storage the graphs highlight problems with negative rental prices.

29. In the figure for Agriculture the exogenous capital services curve does not exhibit the same pattern as the other series. The reason behind this is that there is volatility in land prices that leads to a negative rental price for land in a number of years when an exogenous rate of return equal to 4 per cent plus the CPI is used. For Agriculture, forestry & fishing, land contributes significantly to the overall capital stock and has fallen in price over the period. Consequently, the aggregation to total gross rentals (rental price multiplied by productive capital stock) gives a negative value for land and for total assets. This means that the asset weights for all assets other than land become negative. However, land does not contribute to the capital services index as the productive capital stock of land does not change over time. Therefore, it is not the large weights for land themselves that lead to the wayward capital services index such as the one shown in figure 2 but their distorting effect on the weights for other assets. While this effect is shown occurring for exogenous rates it also occurs for endogenous rates but a further adjustment has been made to the rental price.

30. For the Transport & storage industry negative rental prices occur using an endogenous rate of return whether price deflator is the CPI or an asset price deflator. The negative rental price occurs across a number of assets over various years, with the most common being land and non-dwelling construction. Despite the negative rental prices occurring for both endogenous estimates, the index using the asset price deflators produces a seemingly plausible estimate. Further investigation is aimed at using a mix of asset price deflators and the CPI, with the idea being to form a better ex ante measure of producer's asset inflation expectations, not just for this industry but across all industries.

31. Table 5 shows the growth rates of capital services index for selected time periods based on different rates of return. For the majority of time periods and industries, the growth rates do not differ substantially with the choice of rate of return. However, some differences do exist. For example, for Transport & storage, the growth rate based on an endogenous rate of return is higher than the growth rate based on an exogenous rate of return. This is also reflected in the graph in Figure 2, where there is evidence of convergence of the indexes from 1990 onwards.

32. With the exception of the two series within Agriculture, forestry & fishing, and Transport & storage the growth rates of the capital services indices do not differ substantially with the choice of rate of return or the asset price deflator. Thus the subsequent impact on growth rates of MFP estimates should also not differ substantially, assuming every thing else remains constant. However, the use of the CPI appears to show that for the majority of industries growth in the capital services index was slower, which would lead to faster growth in MFP as opposed to using the asset price deflators. While the differences are likely to be small, they still can influence how MFP is interpreted.

Table 5: Annual average growth in capital services index for the market sector industries
Per cent per year

	<i>1964-65 to 1994-95</i>		<i>1994-95 to 2004-05</i>		<i>1964-65 to 2004-05</i>	
	<i>Exogenous</i>	<i>Endogenous</i>	<i>Exogenous</i>	<i>Endogenous</i>	<i>Exogenous</i>	<i>Endogenous</i>
Agriculture, forestry & fishing	-1.59	1.01	0.01	0.11	-1.19	0.78
Mining	7.87	7.78	4.11	4.13	6.93	6.87
Manufacturing	2.94	2.96	3.14	3.17	2.99	3.01
Electricity, gas & water	3.02	3.55	2.94	3.78	3.00	3.61
Construction	5.64	5.76	3.50	3.19	5.10	5.12
Wholesale trade	4.74	4.95	4.62	4.89	4.71	4.93
Retail trade	4.45	4.69	5.03	5.03	4.60	4.78
Accommodation, cafes & restaurants	5.40	5.82	4.84	5.18	5.26	5.66
Transport & storage	3.53	5.43	2.84	4.15	3.36	5.11
Communication services	6.29	6.40	6.98	6.91	6.46	6.53
Finance & insurance	8.33	8.54	6.41	5.53	7.85	7.79
Cultural & recreational services	5.86	5.93	7.24	7.60	6.21	6.35

3.2 Future Work for Capital Services

33. The future work on capital services is to undertake further sensitivity analysis on various aspects of capital services measurement. One area is to examine other components of the user cost of capital equation such as the rate of depreciation, and capital gains. Further to this, we will examine how different methods of depreciation, different age-efficiency profiles, and mean asset lives impact on capital services, and the corresponding MFP estimates.

34. The choice of age efficiency profile impacts capital services estimates through the Perpetual Inventory Method (PIM). Currently, the ABS uses a hyperbolic age efficiency profile in the calculation of capital services. A hyperbolic profile implies that the productive services of an asset decrease slowly at the beginning of the asset's life and then decreases at an increasing rate in later periods. While there is no strong evidence against using a hyperbolic age efficiency profile, investigating alternative profiles may still be beneficial. A geometric age efficiency profile is the most common alternative to a hyperbolic profile. A geometric age efficiency profile implies the efficiency of an asset decreases at a constant rate.

35. Another area for exploration in the age-efficiency profiles is the efficiency parameters used in the hyperbolic profile equation. The efficiency parameters currently used by the ABS are 0.5 for equipment, software and livestock, 0.75 for construction, 1 for mineral exploration, and 0 for artistic originals. If the hyperbolic age efficiency profile is continued to be used, then further investigation into the efficiency parameters may be warranted. In particular, the sensitivity of MFP estimates to changes in the parameters may be of interest.

36. The choice of age efficiency profile determines the age price profile of an asset. The choice of age price profile has an impact on the depreciation rate. An age price profile is used to determine the net capital stock, which in turn is used to derive the depreciation rate.

37. Mean asset lives are an important component in the measurement of capital stock and vary by asset type. Asset lives are influenced by a number of variables including changes in technology, quality changes, and changes in the rate of use. While the ABS has adjusted mean asset lives for some assets as more information has become available, the mean asset lives used currently are based on asset lives from 1996-97 which may not accurately reflect current mean asset lives. For example, in 1996-97, the mean asset life for computers was 4.9 years, which may be too high for the current period. An investigation into the sensitivity of MFP estimates to changes in mean asset lives may be warranted.

38. One final aspect of capital services estimation to consider is asset life distributions. Asset life distributions are the extent to which assets are retired before, on, or after the mean asset lives. The approach used by the ABS assumes that for most asset types, the lives of assets vary about the mean according to a Winfrey S3 probability distribution - a bell-shaped symmetric function, with about 75 % of assets retiring within 30% of the mean life. While a number of distributions exist, the only other plausible alternatives to the Winfrey S3 pattern are other bell-shaped curves, or delayed linear patterns. It may be beneficial to investigate the impact of various mortality patterns on MFP estimates.

4. *Measuring labour inputs*

39. An important aspect in measuring industry productivity is accurate estimates of hours worked by industry. As part of the ABS's work program to enhance its productivity measures, it is reviewing measures of hours worked by industry. The productivity measures presented in section 2 use hours worked by industry from the

Labour Force Survey (LFS). The total hours worked estimates by industry are the product of industry employment and average hours worked per person.

40. There has been discussion of the quality of the industry employment figures in the Labour Force Survey (LFS), which form part of the hours worked estimate, noting that the concern lies with the accuracy of the industry employment numbers, not total employment which are considered to be of a high quality. The main reason for the concern around the industry employment numbers is that the LFS is not stratified by industry, hence movements in the industry employment numbers can be subject to notable sampling error.

41. However, using the LFS for industry hours worked does have some strong advantages. Business surveys tend not to record hours worked information. The LFS records full hours worked and employment information for employees and the self employed whilst business surveys tend only to have employment data for employees. Since the self-employed constitute around 15% of the Australian work force and have different patterns of work than employees the availability of hours worked data including the self-employed is a significant benefit of LFS data over business surveys. The LFS also has a consistent uninterrupted time series and if the ABS were to use business surveys a hybrid of two different data sources would be needed.

42. Business surveys on the other hand, tend to provide more accurate industry allocation due to industry stratification and the linking of industry to a business register. Even where inaccuracies exist since the industry definition is consistent between the employment and data used to measure GDP and capital formation there is a greater likelihood of consistency between the components of the productivity equation.

43. In this section a new methodology is explained using business survey data from the Survey of Employment and Earnings (SEE) and modelled employment data based on data from the linked Economic Activity Survey (EAS) and Business Income Tax (BIT) dataset. These business survey based estimates are used to estimate total hours worked for the industry, using industry average hours worked from the LFS. These industry hours worked are benchmarked with the total LFS hours worked as it is more reliable at the aggregate level. The hypothesis is that by utilising a more appropriate industry allocation methodology there should be more reliable measures of industry multifactor and labour productivity.

44. The ABS is also researching estimates of aggregate hours worked, which are derived from average hours worked per person. Currently the ABS uses only the four reference weeks from the LFS in the mid-month of each quarter. A new methodology adopting the Statistics Canada approach of using the full 12 LFS reference weeks is likely to be used in the next annual national accounts. This new approach has little impact on growth rates in hours worked but has significantly changed the level of hours worked which matters in international comparisons.

4.1 Alternative methodology

45. The alternative estimates of industry employment use data from SEE up until 2000-01 and the modelled employment dataset for subsequent years. Total hours

worked from the LFS is used as a benchmark and the industry shares from SEE and modelled employment data are applied to this. There are two main methodological issues:

- the business survey based employment data only include employees, therefore the employer and self-employed counts by industry from the LFS are prorated to the employment SEE data.
- there are no data for Agriculture, forestry & fishing, or Finance & insurance in the EAS dataset, and hence LFS data are used for these industries throughout the time series. The shares of total hours worked using SEE and modelled employment data are then applied to the LFS aggregate hours benchmark.

46. The modelled employment estimates are based on wages and employment data in EAS data set to provide an estimated equation that can impute employee numbers for establishments on the BIT dataset, which contains only wages data.

4.2 Comparison of Employment Proportions by Industry

47. Table 6 below is a comparison of employment percentages by industry using different data sources for the start and end points of the time series. The first series is the linked SEE and modelled employment data series. The second series is the LFS. Despite the differences in the methodologies there appear to be no significant differences in industry shares.

Table 6: Employment share by industry for SEE and modelled employment data and LFS for 1985-86 and 2003-04
Per cent

	1985-86		2003-04	
	<i>SEE & ModEmp</i>	<i>LFS</i>	<i>SEE & ModEmp</i>	<i>LFS</i>
Agriculture, forestry & fishing	7.8	8.9	6.0	6.3
Mining	2.1	2.4	1.4	1.6
Manufacturing	24.4	24.5	17.9	18.0
Electricity, gas & Water	2.9	2.8	1.0	1.3
Construction	10.1	10.4	12.8	13.3
Wholesale trade	7.5	7.7	8.4	7.5
Retail trade	21.1	19.3	25.7	24.2
Accommodation, cafes & restaurants	6.3	4.7	7.8	7.9
Transport & storage	7.5	7.3	7.5	7.2
Communication services	2.7	3.1	2.3	2.8
Finance & insurance	5.4	6.1	5.5	5.8
Cultural & recreational services	2.3	2.7	3.7	4.0

4.3 Comparison of Growth Rates for Hours Worked

48. Table 7 below is a comparison of annual average growth rates for hours worked from 1985-86 to 1994-95 and 1994-95 to 2003-04 for the linked SEE and modelled employment dataset, and the LFS.

Table 7: Average annual growth rates in hours worked for SEE & modelled employment data and LFS, selected periods.
Per cent per year

	1985-86 to 1994-95		1994-95 to 2003-04	
	SEE & ModEmp	LFS	SEE & ModEmp	LFS
Agriculture, forestry & fishing	-0.5	-1.0	-1.5	-1.3
Mining	-0.3	-0.4	0.6	1.7
Manufacturing	0.2	0.5	-1.4	-0.6
Electricity, gas & Water	-5.0	-4.6	-4.1	-1.3
Construction	2.9	2.7	2.2	3.2
Wholesale trade	2.1	2.1	1.2	-1.3
Retail trade	1.5	1.9	1.0	1.2
Accommodation, cafes & restaurants	2.9	5.3	0.8	2.2
Transport & storage	1.4	1.1	1.0	1.4
Communication services	0.2	0.7	1.0	1.8
Finance & insurance	1.9	1.0	-0.5	1.2
Cultural & recreational services	5.0	4.3	1.5	2.0

49. The data in table 7 shows that there are some significant differences in the both periods, the most notable being Accommodation, cafes & restaurants. In the first period the other big difference occurs in the Finance & insurance industry. In the latter decade there are larger differences across a range of industries.

50. Preliminary analysis comparing the effect the two series has on MFP growth shows that MFP using the LFS series as the labour input has slower growth for most industries. The only exceptions are Agriculture, forestry and fishing, Finance & insurance, Transport & storage, which had similar growth rates, and Wholesale trade where MFP using LFS was faster than the SEE / modelled series. Work will continue towards defining the most appropriate measures of labour input by industry.

5. Aggregation issues

51. Concurrent with measuring industry level MFP, the ABS will continue to estimate aggregate market sector MFP. This aggregate measure can be estimated directly or by summing the individual MFP estimates, but different results would be obtained. The motivation for this is that if the ABS is to publish industry level MFP estimates then there is the issue of consistency between the current method and any alternative set of results. Compiling the industry level estimates would raise analytical questions as to their contributions to aggregate MFP growth. This section reviews the current methodology, and discusses an alternative methodology.

52. The focus is on a value added based measure of MFP. An alternative to a value added based measure of MFP is a gross output based measure. That is, where gross output is the 'output' variable in the MFP calculation. The gross output measure is not examined here as an alternative in considering an aggregate measure of MFP for three reasons. First, the focus is on issues that relate to value added based MFP because this is what is currently used for the market sector. Any comparisons between gross output and value added based measures may conjure up further issues to consider in the realm of an aggregate MFP measure. Thus, for brevity the focus will remain on value added.

53. The second issue is that there has been no further work on gross output based measures of MFP by the ABS at this stage. However, this is on the forward work program. Finally, any productivity measure based on gross output only has data available from 1994-95, whereas value added data are available from 1964-65 for the market sector and from 1984-85 for industry data.

5.1 Current methodology

54. The ABS currently publishes productivity estimates for the market sector. The current method that the ABS uses for estimating market sector MFP is commonly termed the ‘top-down’ approach.

55. Put simply, the approach involves estimating aggregate indexes for output, capital and labour and then estimating an aggregate MFP estimate. The aggregate index for output involves summing individual volume estimates of value added for market sector industries and constructing an aggregate volume index from this. The aggregate index for labour inputs for the market sector is obtained by deducting estimates of total hours worked for the non-market sector from the ‘All industries’ estimate of total hours worked.

56. The aggregate capital services index is calculated using a two stage process. The first stage produces industry level capital services, based on the perpetual inventory method. The second stage involves weighting the industry capital services indexes to form an aggregate capital services index. Industry gross operating surplus shares form the weights and are applied to the industry capital services indexes to form an aggregate Tornqvist.

57. The aggregate labour and capital indexes are then combined using their respective income shares to form an aggregate input index using a Tornqvist methodology.

58. The final step is the calculation of MFP, which is output divided by input. One point to note is that the index for output, value added in this instance, for the market sector is a Laspeyres index as opposed to the Tornqvist index used for the inputs. The use of a Laspeyres index makes it consistent with the economy-wide volume measure of output, namely GDP.

5.2 Alternative value added methodology

59. The alternative method for estimating an aggregate measure for MFP involves using industry level estimates of MFP weighted together to form a market sector MFP. This method is commonly termed the ‘bottom-up’ approach.

60. One approach is to aggregate each industry’s MFP by the industry’s current price share of value added, since the current price industry-level value added sums to the market sector value added. However, growth in this form of aggregate MFP will not generally be equal to an aggregate MFP measure based on the ‘top down’

approach. This is because the top down approach captures changes in the distribution of industry value added and in the industry distribution of capital and labour.

61. This method of weighting industry MFP means that an aggregate MFP measure is dependent on the distribution of industry value added. Thus, the interpretation for market sector MFP growth would depend on industry productivity growth and on changes in the distribution of value added. To some extent this is Baumol's disease, that is, aggregate MFP growth will be reduced if the value added shares of the low productivity industries are increasing in the economy.

62. An alternative weight to use is employment, but the issues of distribution remain, but with the focus on industry employment distribution.

5.3 Reconciling the two approaches

63. Methodological differences between the two measures mean that the top down approach captures the changes in the industry distribution of value added, capital and labour. That is, the industry reallocation of all three of these affects aggregate productivity growth. Zheng (2005) in his paper decomposes the top-down approach into (i) the industry-level approach (bottom-up), (ii) the reallocation of value added and (iii) the reallocation of primary inputs. Simply:

$$\text{Aggregate approach} = \text{Industry-approach} + \text{contribution of reallocation of industry value added} + \text{contribution of reallocation industry primary inputs.}$$

64. Zheng has followed the approach in Jorgenson, Gollop and Fraumeni (1987), which is also discussed in Oulton and O'Mahony (1994).

65. Overall, there needs to be consideration as to the approach to take, as well as the interpretation of the aggregate MFP measures.

6. Issues around interpretation

66. Further to the issues surrounding the data for use in measuring industry level productivity there is the issue of interpreting the results. That is, does the MFP estimate accurately reflect what is really occurring? To do this properly requires in depth investigations of each industry. A brief look at the Mining industry was chosen because of its current high profile in Australia due to the recent resources boom that is occurring.

6.1 Mining case study

67. MFP for the Mining industry grew steadily in the years to 2001, but has subsequently declined (see Figure 3). However, since 2001 the Mining industry has had significant increases in income. To some extent this is shown in the figure 4 in the gross operating surplus series. This increase in income comes from higher prices for exports of Australian resources, which can be seen in Australia's rising terms of

trade. These gains in income have raised the question as to why productivity has not followed suit. To answer this question the MFP results need to be deconstructed.

Figure 3: MFP, labour productivity, and capital productivity for the Mining industry, 1984-85 to 2004-05 (Experimental estimates)
Index 2003-04=100

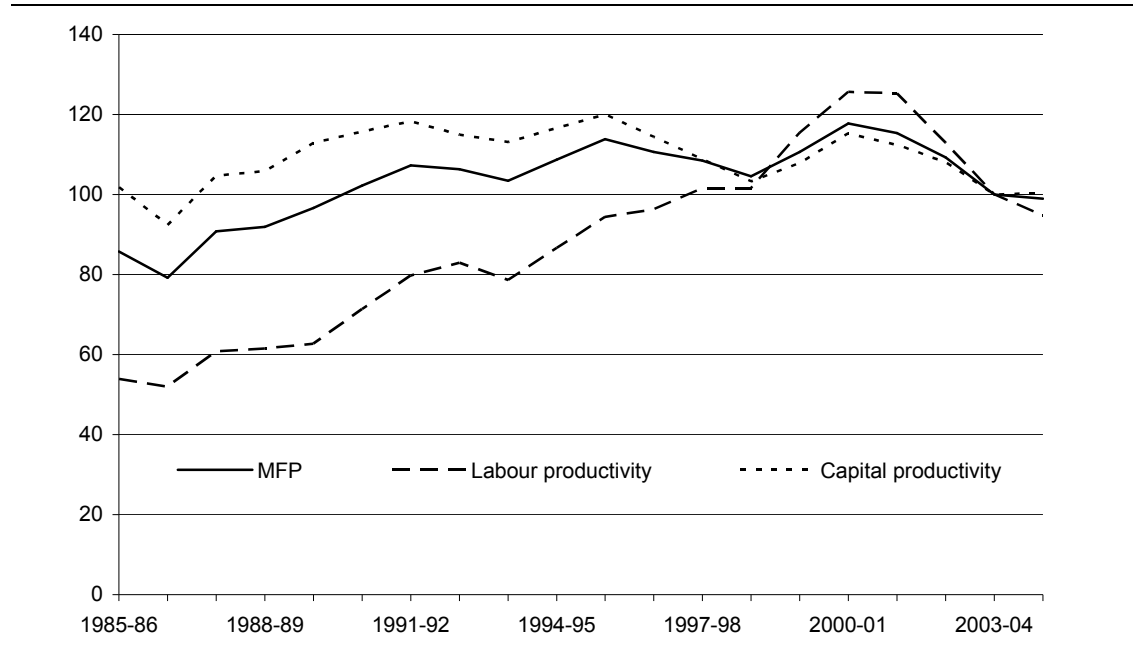
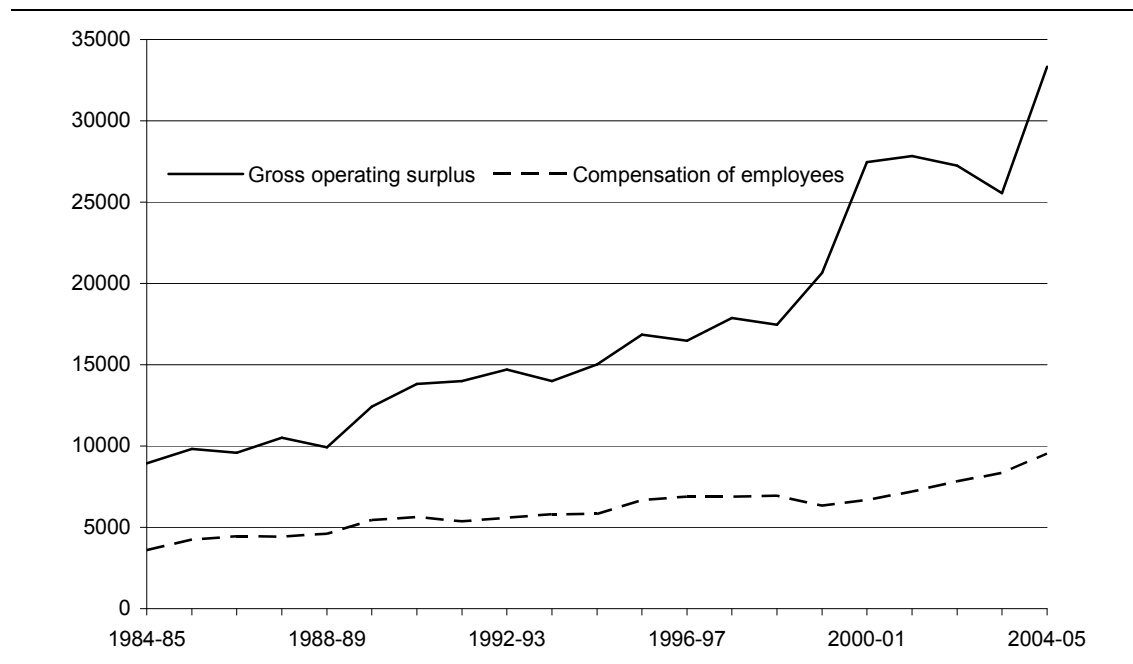


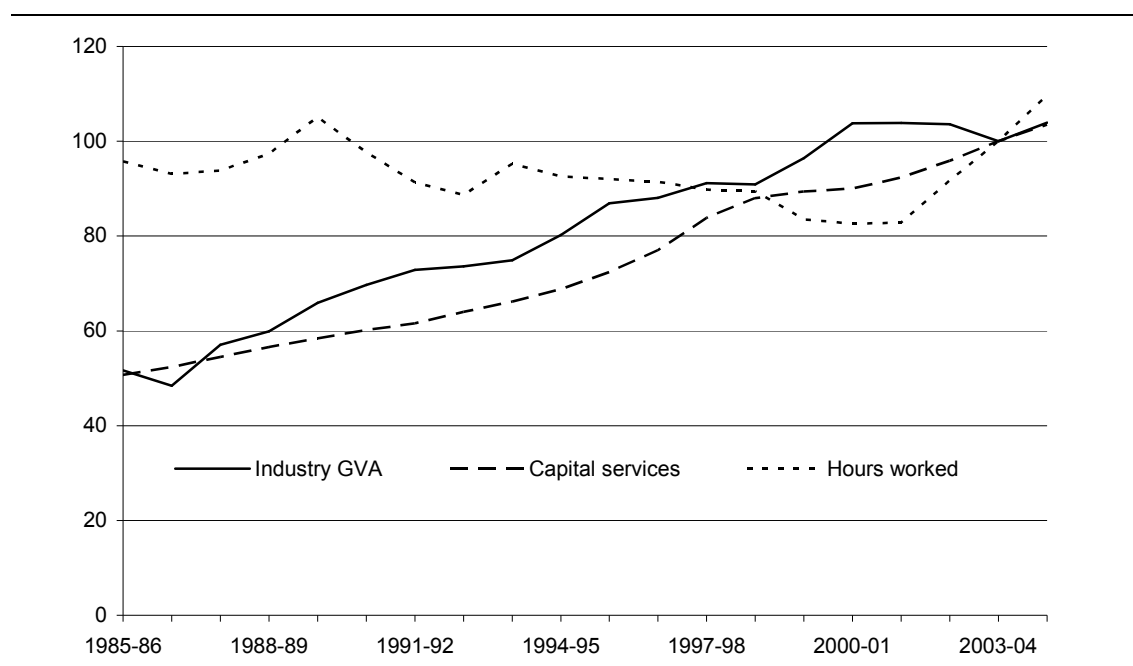
Figure 4: Gross operating surplus and compensation of employees for the Mining industry, 1984-85 to 2004-05
\$million



68. The first component of MFP to examine is output. Figure 5 shows that there has been no growth in output since 2000, which means that the decline in MFP has come from increasing growth in inputs. For capital services it appears that there was a

slight slowdown in 2000, but it resumed trend growth in the following years. The growth in labour inputs is another possible explanation for the decline in MFP. The data shows labour employment, and hence total hours worked, has increased rapidly over the last few years, increasing by more than 30 per cent since 2001-02. However, the labour share is relatively small compared to capital. Overall, the decline in Mining MFP over recent years is due to a combination of a return to trend growth in capital services, relatively strong growth in labour inputs and no growth in output.

Figure 5: Output, labour and capital inputs for the Mining industry, 1984-85 to 2004-05
Index 2003-04=100

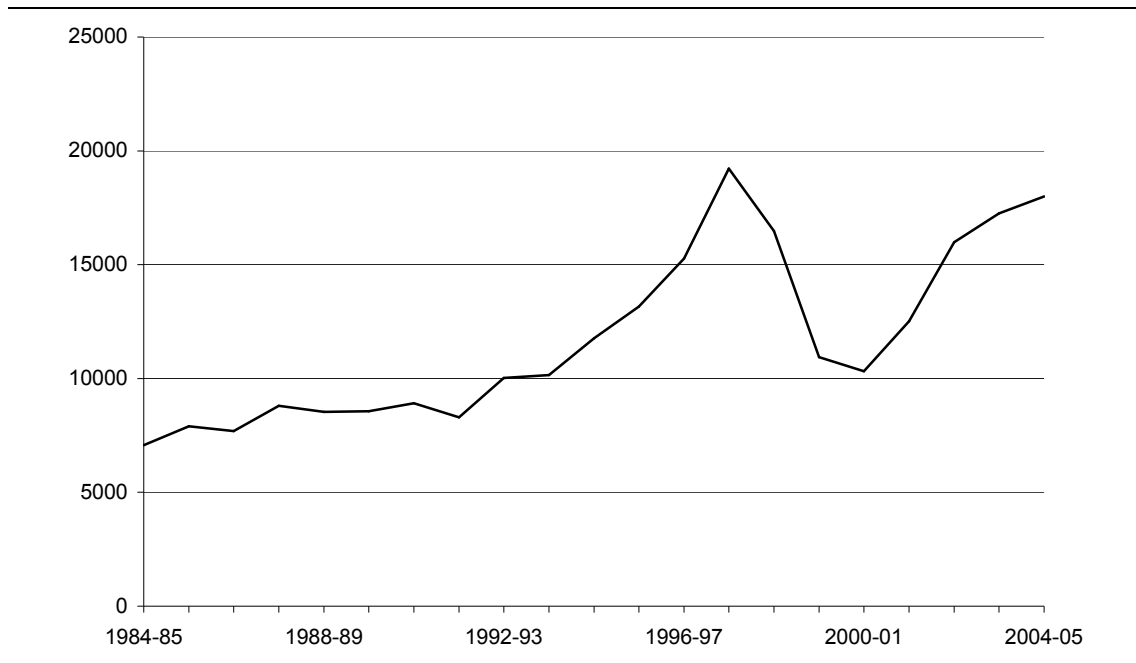


69. If, as the data shows, that there have been significant increases in income then it would be expected that investment would follow suit to capture these gains. The slowdown in capital services in 2000 was due to a significant fall in investment in 1999-00, but has since rebounded, although in volume terms this rebound seems to have returned the series to a trend growth rate (see figure 6).

70. Even though investment has been increasing in recent years there may be a lag until there is any production as another reason that might explain the slowdown in productivity. That is, gross fixed capital formation is recorded when the expenditure is made, but there may be some time before anything is produced from this investment, which means that inputs are growing but without any growth in output. At present, this matter is not adjusted for in the capital service estimates.

71. There is some anecdotal evidence that might suggest that MFP in the Mining industry is either declining or its growth is flat. For instance, less efficient mines come online when a resource reaches a particular price. That is, the mine became cost efficient to engage in production. If this is widespread then there is likely to be a compositional effect that reduces productivity for the Mining industry. However, further investigation is required to examine the extent that this is occurring.

Figure 6: Gross fixed capital formation volumes for the Mining industry, 1984-85 to 2004-05
\$ 2003-04 million



72. Two final issues to consider when interpreting Mining MFP estimates are the scope of assets and the treatment of mineral exploration. Subsoil assets are not included in the capital services measure for Mining at present and further work in this area is required. The second issue is the treatment of the efficiency decline for mineral exploration. The ABS treatment is such that it is assumed that there is no decline in the efficiency of mineral exploration, that is, the assets efficiency decline is represented as a one-hoss shay. The assumption is that there is no decline in exploration knowledge.

73. In summing up it appears that there is no necessary reason why Mining MFP should have increased even though incomes have increased. The evidence appears to point to MFP declining or having very little growth. There was no growth in output accompanying the growth in inputs. There is the significant increase in labour inputs, which has come from an increase in employment. While investment volumes have been increasing they have yet to reach the previous high levels in the late 1990s. There is also the possibility that there are lags in new investment becoming productive as a reason why productivity is declining but this requires further investigation to provide information on the extent that this is occurring. Despite not being able to draw any absolute conclusions, the evidence to date appears to show that the MFP results for the Mining industry appear plausible.

7. Future directions

74. Future directions for industry MFP measures will be to build on the Mining case study with further industry case studies. Further questions could be asked of the data such as, what is the quality of the current coding of units to these industries on the business register? What is the quality of the current output and sales data for wholesale and retail? What is the quality of the output deflators used to get volume

estimates for the industries? What is the quality of the intermediate input structures? What is the quality of the income shares for these industries? What is the quality of the labour input data for these industries? What is the quality of the capital data for these industries considering in particular the implied return on capital and the current asset mix? Further work will also test the sensitivity of all results.

75. The ABS is also investigating growth cycle issues. The aim is to try and get a good way of comparing productivity over time. This requires developing appropriate estimates of productivity numbers, and likewise, appropriate methods of determining the productivity cycle. The work will examine the questions of what method is best for determining a productivity cycle (that is, determining peaks in the productivity series); how industries' contribution to the observed productivity cycle differ; and how capacity utilisation may be taken into account when comparing productivity peaks. The immediate concern is reviewing (and explaining the choice of) the current method for estimating growth cycles in the productivity series.

76. Overall, the ABS's productivity work is progressing well but a significant amount of investigation and testing is still required. Although the work poses challenges and questions core elements of the national accounts data set, the application of a growth accounting framework at the industry level will help to increase the overall coherence and quality of the accounts.

77. For further information on the ABS' productivity work program contact Paul Roberts on 02 6252 5360 or email paul.roberts@abs.gov.au

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