E Sensitivity analysis of MFP estimates

Much of the analysis in this paper relies on the validity of the subsector multifactor productivity (MFP) estimates produced in this study. It is, therefore, worthwhile examining how sensitive these estimates are to different data and assumptions used in their estimation (given the limitations discussed in appendix A). The first part of this appendix tests the sensitivity of the MFP estimates by recalculating them using alternate treatments of capital data. The second part of this appendix discusses whether survey error in the measures of inputs and outputs is a likely explanation of MFP growth rates over cycle 4 becoming negative.

The analysis suggests that, regardless of the data source used or the scenario compared against, there was a notable decline in Manufacturing MFP from cycle 3 to cycle 4, and that it was generally driven by the three subsectors focused on in this paper.

## E.1 Effects on MFP of using different data and assumptions

#### Using an alternative investment measure

As noted in the body of the report, and in more detail in appendix A, the two main capital investment series published by the ABS diverge for Manufacturing over the period of cycle 4 (2003-04 to 2007-08), before showing signs of convergence in the incomplete cycle. The gross fixed capital formation (GFCF) series grows faster in cycle 4 relative to private new capital expenditure (PNCE). The former is used by the ABS and in this paper to form the capital input used to derive MFP estimates[[1]](#footnote-1), but it does raise the question as to whether MFP estimates would be materially different if the PNCE levels (rather than just its subsector shares) were used instead.

The methodology for testing such an assumption is straightforward. Rather than using the GFCF-based measure of non-dwelling construction and machinery and equipment (the two principal asset types that form the majority of Manufacturing investment), PNCE is used instead. No change is made for the other asset types — Research and Development (R&D) and Software.[[2]](#footnote-2)

The gap between GFCF and PNCE is largest in cycle 4 (the period of poor productivity) and so the choice of investment series used has the greatest effect over the 2003-04 to 2007-08 period. Table E.1 shows the resulting change in (income-share weighted) capital services growth for each of the subsectors. The effect, on aggregate, is that income-share weighted capital services growth for Manufacturing in total is 1.1 percentage points slower (per year) over cycle 4 when the PNCE measure is used (relative to the GFCF measure).

Table E.1 Growth in income-share weighted capital services in cycle 4

Average annual growth rate (per cent)

|  |  |  |  |
| --- | --- | --- | --- |
| Subsector | GFCF-apportioned growth | PNCE-derived growth | Difference |
| Food, beverage & tobacco products | 2.1 | 1.0 | -1.1 |
| Textile, clothing & other mfg | 0.5 | -0.1 | -0.6 |
| Wood & paper products | 1.7 | 0.6 | -1.1 |
| Printing & recorded media | 1.8 | 0.8 | -0.9 |
| Petroleum, coal, chemical & rubber prod. | 3.7 | 2.6 | -1.1 |
| Non-metallic mineral products | 0.4 | -0.6 | -1.0 |
| Metal products | 4.6 | 2.9 | -1.7 |
| Machinery & equipment mfg | 1.4 | 0.8 | -0.6 |
| *Aggregate of subsectors* | *2.5* | *1.4* | *-1.1* |
| **Total Manufacturing (ABS)**a | **2.4** | **na** | **na** |

a Corresponding figure published by the ABS.

*Sources*: ABS (*Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.55.0.001); authors’ estimates based on ABS (*Private New Capital Expenditure and Expected Expenditure,* various issues,Cat. no. 5625.0).

The greatest effect in moving to a PNCE-based measure is in Metal products, where capital services growth is much slower under the PNCE-based measure. In addition, the PNCE-based measure gives Non-metallic mineral products and Textiles, clothing and other manufacturing negative capital services growth over cycle 4, compared with positive growth under the GFCF-based measure.

The change in capital services has an effect on MFP growth, and in turn affects the contributions made by the different subsectors over the period from cycle 3 to cycle 4. Table E.2 shows the capital contribution made to MFP growth for the GFCF- and PNCE-based measures between cycles 3 and 4.

Table E.2 Subsector contributions to the change in Manufacturing MFP growth between cycles 3 and 4, based on GFCF-apportioned and PNCE-based capital services measures**a**

Percentage points

|  |  |  |  |
| --- | --- | --- | --- |
| Subsector | GFCF-apportioned MFP | PNCE-based MFP | Difference |
| Food, beverage & tobacco products | -0.73 | -0.65 | 0.08 |
| Textile, clothing & other mfg | -0.40 | -0.38 | 0.02 |
| Wood & paper products | 0.03 | 0.05 | 0.02 |
| Printing & recorded media | -0.35 | -0.33 | 0.02 |
| Petroleum, coal, chemical & rubber prod. | -0.81 | -0.81 | 0.00 |
| Non-metallic mineral products | -0.07 | -0.05 | 0.02 |
| Metal products | -0.42 | -0.25 | 0.17 |
| Machinery & equipment mfg | -0.32 | -0.28 | 0.05 |
| **Aggregate of subsectors**b | **-3.08** | **-2.70** | **0.38** |

a Note that the contributions are negative, as growth in capital inputs reduces MFP growth. b The sum of contributions. Based on methodology discussed in Parham (2012).

*Source*: Authors’ estimates.

The use of a PNCE-based capital services measures reduces the decline in productivity from cycle 3 to cycle 4, but there is still a marked decline in Manufacturing MFP regardless of which series is used. Within Manufacturing, the use of the PNCE-based measure of capital services does have an effect on contributions of the different subsectors; the largest being on Metal products.[[3]](#footnote-3) The PNCE-based measure still indicates that Petroleum, coal, chemical and rubber products and Food, beverage and tobacco products contributed the most to the MFP decline from cycle 3 to cycle 4, while Metal products makes a lesser contribution compared with Textiles, clothing and other manufacturing, Printing and recorded media and Machinery and equipment manufacturing.

In short, PNCE represents a lower level of investment relative to GFCF and therefore raises the level of MFP in both cycles. In doing so, although it has a more positive effect on MFP in cycle 4, it preserves most of the difference between the two cycles and therefore does not significantly affect the decline in MFP that occurs from cycle 3 to cycle 4 (figure E.1).

Figure E.1 Rates of MFP growth in Manufacturing based on capital measure used

Average annual growth rate (per cent)

|  |
| --- |
|  |

*Data source*: Authors’ estimates.

#### Effect of removing R&D from the capital services measure

The estimates of MFP presented in this paper are consistent with the present ABS treatment of R&D expenditure, which is to record such expenditure as a capital input, rather than an intermediate input.[[4]](#footnote-4) It is worthwhile checking the extent to which growth in R&D contributes to growth in subsector capital services, given the variety of R&D intensities at that level of disaggregation.

R&D expenditure makes up a small proportion of investment, but grew more quickly than the rest of investment over cycle 4. Because the lag between when R&D is undertaken and when output associated with that R&D occurs can be large, it is possible that the growth in R&D expenditure in cycle 4 could manifest as a productivity decline.

A way to test this hypothesis is to remove R&D from the capital services measure published by the ABS for Manufacturing in total. The effect on the resulting capital services index is very small (figure E.2), with capital services growth being marginally slower when R&D is excluded.

Figure E.2 Manufacturing capital services with and without R&D

Index 2009-10 = 100

|  |
| --- |
|  |

*Data source*: Authors’ estimates based on ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

While there is no great effect in aggregate, it could be possible that excluding R&D could have a proportionally greater effect on particular R&D intensive subsectors within Manufacturing. This is most readily shown by the contribution to capital services made by R&D (table E.3). For example, in cycle 3, R&D contributed a total of 0.07 to the 2.47 percentage points growth in Manufacturing capital services. At the subsector level, there is little effect of R&D on total capital services growth.

Table E.3 Contributions to capital services growth attributable to R&D

Percentage points

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Subsector | Cycle 1:  1988-89 to 1993-94 | Cycle 2:  1993-94 to  1998-99 | Cycle 3:  1998-99 to  2003-04 | Cycle 4:  2003-04 to  2007-08 |
| Food, beverage & tobacco products | 0.01 | 0.00 | 0.01 | 0.01 |
| Textile, clothing & other mfg | 0.00 | 0.00 | 0.00 | 0.00 |
| Wood & paper products | 0.01 | 0.00 | 0.00 | 0.00 |
| Printing & recorded media | 0.00 | 0.00 | 0.00 | 0.00 |
| Petroleum, coal, chemical & rubber prod. | 0.01 | 0.01 | 0.02 | 0.02 |
| Non-metallic mineral products | 0.00 | 0.00 | 0.00 | 0.00 |
| Metal products | 0.02 | 0.01 | 0.01 | 0.01 |
| Machinery & equipment mfg | 0.03 | 0.02 | 0.03 | 0.02 |
| *Manufacturing* | 0.07 | 0.05 | 0.07 | 0.03 |
| **Manufacturing**a **(all assets)** | **1.25** | **1.40** | **2.47** | **1.17** |

a Denotes the total capital services growth for Manufacturing as a whole.

*Source*: Authors’ estimates.

It seems reasonable to conclude, then, that R&D has not had a large effect on capital services growth, and so even if there were a lag between investment and output linked to R&D, the effect of the investment is so small as not to alter the observed trends in MFP in Manufacturing at either the aggregate or subsector level.

## E.2 Is survey error a likely explanation of MFP growth falling below zero?

A statistical error can be introduced when data derived from a survey are used to represent a population. This error can be quite large (depending on the survey sample design).

Because many variables used to calculate MFP are derived from survey data, there is a question as to whether the observed trends are what actually happened in the economy, or are the result of sampling or other measurement error. This section determines what the size of the error would have to be in order for MFP growth in Manufacturing to have been zero over cycle 4. This benchmark of zero MFP growth is chosen because the absolute decline in MFP in cycle 4 is the focus of this paper.

It follows that if the change needed for MFP growth to have been zero over cycle 4 is unreasonably large, then it is less likely to have been the result of errors. If, however, the change required is small, then the likelihood of the result being driven by error is more likely — meaning the estimates may be less reliable.

Because MFP growth was less than zero in cycle 4 for Food, beverage and tobacco products, Petroleum, coal, chemical and rubber products, Metal products, and for Manufacturing as a whole, an increase in value added or a large decline in hours worked and capital services would have been necessary in each to achieve zero MFP growth over the same period. The magnitude of these changes required are sufficiently large in each these subsectors so as to indicate that the decline in productivity is unlikely to be the result of statistical error in the data. (Note that this analysis does not address other measurement issues that may affect the data, such as unmeasured quality improvements or the effect of capital lags.)

Table E.4 shows the changes needed for 2007-08 relative to what occurred in that year.[[5]](#footnote-5) For example, in order for Food, beverage and tobacco products to have had zero MFP growth in cycle 4, its value added would needed to have been greater by $4.1 billion in 2007-08 (or an additional 18 per cent relative to what actually occurred).

Table E.4 Changes needed in selected subsectors and Manufacturing in total to achieve zero MFP growth in cycle 4**a**

|  |  |  |
| --- | --- | --- |
|  | Change to 2007-08 estimate | Differenceb |
| **Value added** | Additional value added  (2009-10 $m) | Per cent |
| Food, beverage & tobacco products | 4 154 | 18 |
| Petroleum, coal, chemical & rubber prod. | 3 345 | 17 |
| Metal products | 753 | 3 |
| *Aggregate of subsectors* | *6 951* | *6* |
| **Hours worked** | Additional hours worked  (‘000) | Per cent |
| Food, beverage & tobacco products | -108.1 | -25 |
| Petroleum, coal, chemical & rubber prod. | -64.0 | -32 |
| Metal products | -22.0 | -7 |
| *Aggregate of subsectors* | *-201.2* | *-10* |
| **Net capital stock**c | Additional net capital stock (2009-10 $m) | Per cent |
| Food, beverage & tobacco products | -11 251 | -38 |
| Petroleum, coal, chemical & rubber prod. | -8 144 | -29 |
| Metal products | -3 597 | -8 |
| *Aggregate of subsectors* | *-23 230* | *-15* |

a Specifically, the changes needed to achieve zero MFP growth for Food, beverage & tobacco products, Petroleum, coal, chemical & rubber products, Metal products and aggregate Manufacturing are shown here, separately. b Percentage difference relative to actual 2007-08 values. c Capital inputs are calculated using capital services indexes, which in turn relate to a weighting of productive capital stock (appendix A). Rather than present the weighted productive capital stock, changes in the net capital stock are used here instead to show the magnitude of capital change needed to achieve the outcomes under each of the relevant scenarios.

*Source*: Authors’ estimates.

In terms of value added, the amount of additional output needed to have had zero MFP growth over cycle 4 (rather than negative MFP growth) is quite large for aggregate Manufacturing (an additional 6 per cent), but is even larger for Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products (18 and 17 per cent, respectively). Because Metal products is closer to zero MFP growth to begin with, it requires a comparatively smaller amount of additional value added growth (3 per cent) to achieve zero MFP growth.

A 10 per cent reduction in hours worked would have been necessary in 2007-08 for Manufacturing in total to have achieved zero MFP growth during for cycle 4. A larger reduction in hours worked for 2007-08 are necessary to have achieved zero MFP growth in Food, beverage and tobacco products — in the order of 25 per cent relative to what actually occurred. This reduction is large as it effectively reverses the particularly strong growth of hours worked that Food, beverage and tobacco products experienced over cycle 4.

A reduction of 32 per cent of hours worked in 2007-08 (relative to what actually occurred) would have been necessary for Petroleum, coal, chemical and rubber products to have achieved zero MFP growth in cycle 4. The reason why this reduction is so proportionately large is that Petroleum, coal, chemical and rubber products is particularly capital intensive, and so a reduction in hours worked has a smaller effect on increasing MFP, relative to other subsectors.

In terms of capital services, in order to achieve zero MFP growth for Manufacturing in cycle 4 there would have had to have been a reduction in capital services growth that equates to around 15 per cent of net capital stock. The reductions are comparatively larger for Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products to have achieved zero MFP growth in cycle 4 (38 and 29 per cent, respectively). The reduction necessary in Food, beverage and tobacco products is large as the subsector is relatively labour intensive (and so, reductions in capital inputs have a smaller effect on increasing MFP). The reduction in Petroleum, coal, chemical and rubber products is large as it effectively reduces the very strong capital services growth that occurred in the subsector over cycle 4. The net capital stock of Metal products would have needed to have been 8 per cent smaller in 2007-08 for that subsector to have achieved zero MFP growth.

The changes in proximate causes that would have been necessary to achieve zero MFP growth in cycle 4 are large for aggregate Manufacturing and even larger for Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products. For those two subsectors, the scale of how much additional value added or reduced hours worked and capital services suggests that the negative MFP estimate is unlikely to have been caused simply by random statistical error in the data. The changes necessary for Metal products to have achieved zero MFP growth over cycle 4 are smaller relative to Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products, and are therefore more likely to be sensitive to any statistical error in the underlying statistics. Nevertheless, the required changes for Metal products are still substantial in absolute terms.

1. Total GFCF for Manufacturing is apportioned to the Manufacturing subsectors by the use of PNCE shares in this paper. See appendix A for more detail. [↑](#footnote-ref-1)
2. That is, GFCF-apportioned measures of R&D and Software are used. There are no PNCE data for these asset classes. [↑](#footnote-ref-2)
3. Metal products is more sensitive to the use of the PNCE-based relative to other subsectors because its share of PNCE was rising over cycle 4. Under the GFCF-apportionment method used in the body of this paper, this meant its share of GFCF was rising over cycle 4 — effectively giving the subsector a rising share of a rising investment series. [↑](#footnote-ref-3)
4. Prior to 2008-09, current R&D expenditure was recorded as intermediate inputs by the ABS. The ABS has backcast its capital measures to reflect the change in the treatment of R&D so that its measures remain comparable over time. [↑](#footnote-ref-4)
5. 2007-08 is the end-point of the aggregate Manufacturing productivity cycle, and so changes in the rate of growth over cycle 4 can be effected by changing the level of value added, hours worked and capital services for that year. [↑](#footnote-ref-5)