Australian productivity trends and the effect of structural change

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For a small open economy like Australia, which specialises in commodity exports, fluctuations in the terms of trade and productivity growth are the primary drivers of per capita income growth. Because the global mining sector responds to higher commodity prices by expanding capacity, the terms of trade are unlikely to provide sustained boosts to Australia's living standards. As such, labour productivity is likely to be the main driver of future growth in living standards. This paper analyses trends in Australia's productivity performance and disaggregates productivity growth into industry contributions to evaluate how structural change is affecting productivity growth.

Introduction

Labour productivity growth is, and is expected to continue to be, the key determinant of growth in Australian living standards. In terms of the size of the economy, economic growth is determined by growth in labour utilisation[1] and growth in labour productivity.[2] At an individual level, the primary drivers of per capita income growth are fluctuations in the terms of trade and labour productivity growth.

Because the global mining sector responds to higher commodity prices by expanding capacity, the terms of trade are unlikely to provide sustained boosts to Australia's living standards. As such, labour productivity is likely to be the main driver of future growth in living standards.

Despite concerns, Australia's labour productivity growth over recent years is in line with its longer-term performance. In the five years to 2015-16, labour productivity in the whole economy has grown at an average annual rate of 1.8 per cent. This compares to an average annual rate of 1.4 per cent over the past 15 years and 1.6 per cent over the past 30 years.[3]

Given the importance of labour productivity growth in improving living standards, an understanding of trends in Australia's productivity performance and the impact of structural change on productivity growth can help reveal where we stand and implications for the future. This paper discusses sources of productivity growth in the Australian context, followed by an examination of sectoral productivity growth to highlight how within-sector productivity growth and across-sector productivity growth (or the effects of structural change on productivity) contribute to aggregate productivity growth.

In analysing sources of labour productivity growth, we address the tension between labour productivity growth and multifactor productivity (MFP) metrics. Commentators who view labour productivity growth through the lens of a closed economy neoclassical growth framework have voiced concerns about the slow growth of MFP (Garnaut, 2015). This concern, in large part, stems from the belief that sustainable long-run economic growth must be balanced with output and capital growing at the same rate and that this common growth rate is determined solely by the growth of MFP. Our analysis shows that Australia's labour productivity growth has not been limited by balanced growth or the growth rate of MFP. Australia's labour productivity growth has largely been driven by capital deepening (that is, higher capital per worker) rather than MFP growth.

Sectoral analysis reveals how aggregate productivity growth can be affected by structural change in the economy. In Australia, most sectors have broadly similar productivity levels with the exception of the Mining and Utilities sectors, which have relatively high productivity levels. The movement of workers into and out of the Mining sector is the dominant factor behind the effect of structural change on aggregate productivity growth.

1 Labour utilisation is a function of the ratio of the working age population to the total population; the labour force participation rate; the employment (unemployment) rate; and average hours worked.

2 Labour productivity growth — the key measure of productivity growth — measures growth in output per worker (typically defined on an hours worked basis). Labour productivity growth is driven by increases in the ratio of capital to labour (capital deepening), as well as improvements in the efficiency with which labour and capital inputs are utilised (multifactor productivity).

3 This is not a reason for complacency, however. Mechanically, there would need to be a sustained lift in average annual productivity growth to around 2½ per cent to allow living standards (measured as per capita income) to continue to improve at the long-run historical rate (represented by 30-year average growth in real gross national income per capita) of around 2 per cent per annum.

Outside a Mining boom, where the structural change effect supplements within-sector productivity growth, aggregate productivity growth is driven overwhelmingly by within-sector productivity growth. While within-sector Mining productivity growth is expected to contribute strongly to aggregate productivity growth for the next few years, the large and growing services sectors will remain responsible for growth prospects in the longer term. Efforts to increase productivity in the services sectors will grow in importance into the future.

Sources of aggregate labour productivity growth

Labour productivity growth can be calculated as the sum of capital deepening and MFP growth. Capital deepening is the change in the ratio of capital to labour[4] multiplied by capital's share of factor income. MFP, which is also known as total factor productivity, reflects the overall efficiency with which labour and capital inputs are used together in the production process. In simplified terms, labour productivity growth can therefore be thought of as the sum of: (i) increases in the amount of capital per worker; and (ii) how much better labour and capital work together.

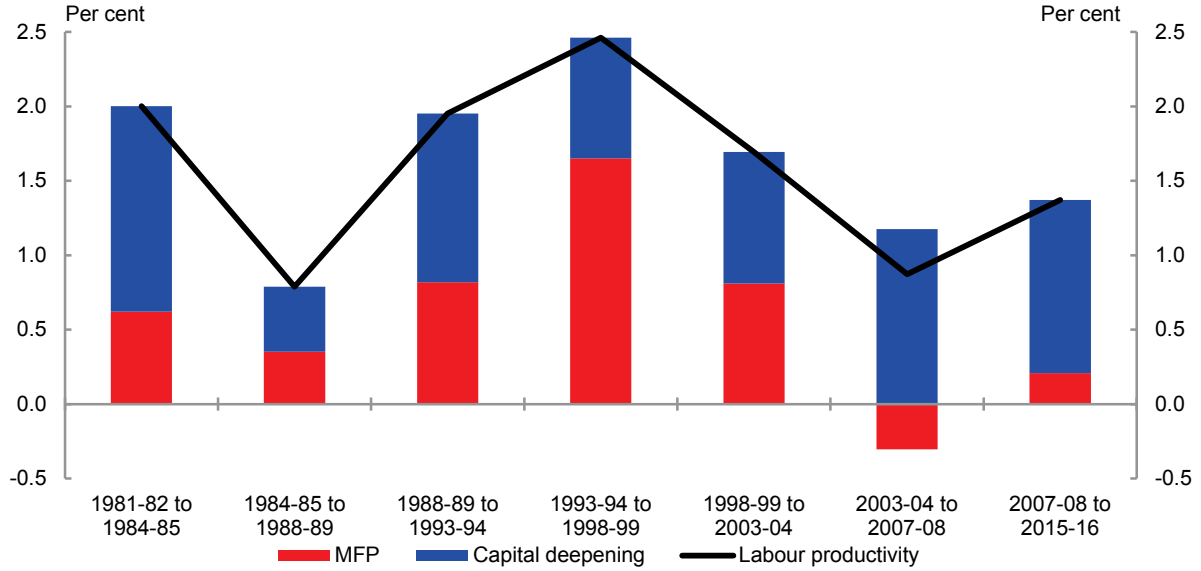
MFP growth can arise for many reasons, including new management practices that allow capital and labour to be combined more effectively or a more efficient allocation of labour and capital across the economy. But unlike output, labour or capital, MFP is not directly observed. Rather, it is calculated as a residual (meaning mismeasurement of labour or capital inputs will be reflected in mismeasured MFP).[5]

Internationally, G7 countries have experienced a slowdown in MFP growth relative to capital deepening over recent decades. Up until around the late 1990s, the contribution of MFP growth to labour productivity in G7 countries was generally at least as important as the contribution of capital deepening. Since then, most of the slowdown in labour productivity growth has been driven by lower MFP growth (OECD, 2015).

The contribution to labour productivity growth in Australia from capital deepening has been higher than the contribution from MFP growth. Of the 30-year average of 1.6 per cent whole-of-economy labour productivity growth, capital deepening contributed 0.9 percentage points and MFP 0.7 percentage points (Chart 1). This is at odds with the balanced growth/MFP growth framework, which implies a contribution from capital deepening equal to capital's share of factor incomes. After rising slowly over the past 30 years, capital's share of factor income in Australia's market sector is currently around 41 per cent (coming off its peak of 44 per cent in 2011-12).[6]

4 Labour being hours worked in our analysis.
5 For example, it can be difficult to accurately measure the volume of capital services.
6 Labour's share of income is therefore currently around 59 per cent. (ABS cat. no. 5260.0.55.002, Table 14).

Chart 1: Labour productivity growth decomposition[7]



Source: ABS cat. no. 5260.0.55.002 and Treasury calculations.

As a source of labour productivity growth, MFP growth is considered to have an important advantage over capital deepening. Neoclassical growth theory implicitly assumes that, unlike capital deepening, MFP growth does not necessarily require an economy to forgo consumption. As such, growth in MFP is generally considered a highly desirable — and sustainable — source of labour productivity growth. That said, improvements in MFP do not come for free, given they usually require the use of other factors of production.

However, Australia has largely avoided the downside to capital deepening-led labour productivity growth. Productivity improvements in the rest of the world have caused a persistent fall in the price of capital goods relative to consumption goods. This has allowed Australia to sustain its high rate of capital deepening without forgoing ever higher levels of consumption.

It is important to note that the relative contribution of capital deepening and MFP may be skewed if new capital takes some time to boost output. For example, during an investment boom the contribution of capital deepening to labour productivity growth may be overstated and the contribution of MFP growth understated for capital with a long-time-to-build. Such a delay in productivity associated with capital investment has been particularly evident in the Mining sector over the past decade — with flow-on effects to whole of economy estimates of capital deepening and MFP growth. With the ending of the Mining investment boom and Mining output continuing to grow over coming years, MFP growth is expected to recover (although potentially be overstated).

Factors driving historical aggregate labour productivity growth

During the 1990s, there was strong growth in aggregate labour productivity (Chart 1). This can largely be attributed to more investment by firms in information and communications technology (ICT) and important microeconomic and macroeconomic reforms introduced since the mid-1980s. The former contributed not only to productivity growth through ICT production but also the use of ICT

7 The time periods on the x-axis are productivity cycles as calculated by the ABS. Productivity growth cycle peaks are determined by comparing the annual MFP estimates with their corresponding long-term trend estimates. The peak deviations between these two series are the primary indicators of a growth cycle peak, although general economic conditions at the time are also considered.

(Gretton, Gali and Parham, 2004). The latter included changes in monetary and fiscal policies, capital markets, industry assistance, taxation, government enterprises, regulation, labour markets and industrial relations, competition policy, innovation and training (Productivity Commission, 1999 and 2004).

These reforms have been shown to have increased competition, promoted more efficient allocation of resources and improved international competitiveness. Some have argued that they also created a competitive environment that has led to permanently higher levels of innovation as businesses anticipated global changes in technology, international competition and tastes (Dolman, 2009).

The resurgence of economy-wide labour productivity growth during the 1990s was led by the services sector. Industries like wholesale trade and financial services seized on new advances in ICT to transform the way they did business. And following the corporatisation and privatisation of their operations, industries like telecommunications and utilities achieved continued productivity growth by scaling back investment levels and substantially reducing their workforces. Productivity levels in these industries rose towards the international technological frontier (Dolman and Gruen, 2012).

However, aggregate labour productivity growth slowed during the 2000s. Several factors contributed to this decline. The Agriculture sector was hit by drought and the Mining and Utilities sectors experienced a fall in productivity as it pursued an 'unrequited acceleration in input use' without a corresponding change in output (Parham, 2012). At a broader level, a reduction of productivity growth in most developed countries would suggest a possible decline in the pace of technological change (Gordon, 2014).

In the end, policy settings that seek to support both capital deepening (by lowering the cost of capital) and MFP improvements (through greater efficiency, innovation and reallocation within existing resource constraints) will support future growth in labour productivity in Australia.

Sectoral analysis

The drivers of aggregate labour productivity growth can be better understood by examining the issue from a sectoral perspective. In particular, doing so provides insights into the role that structural change plays on aggregate productivity growth.

Labour productivity, capital deepening and MFP can each be measured at the sectoral level.[8] In the analysis that follows, the paper disaggregates the economy into six sectors: Agriculture, Forestry and Fishing; Mining; Manufacturing; Utilities; Construction and Services, where Services is an aggregate of all remaining sectors in the Australian economy.[9]

For this analysis, aggregate labour productivity growth comprises two components: a within-sector contribution; and an across-sector contribution, also known as a structural change effect. The former

8 Although data is unfortunately only available from 1988-89 to 2015-16.

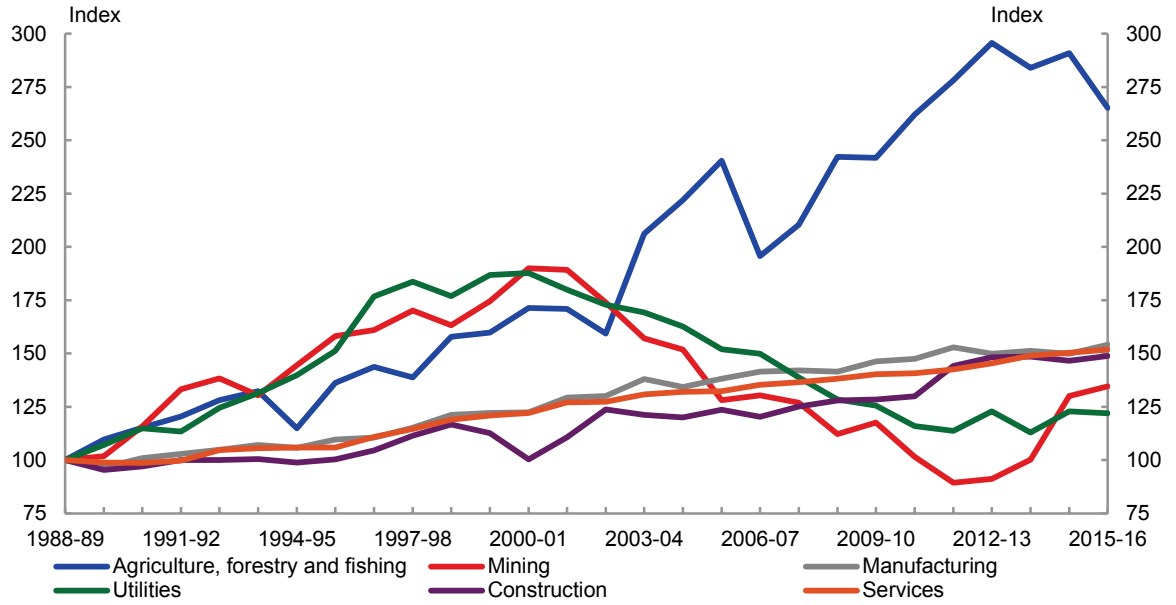
9 The 'services sectors' are the combination of the following sectors: Wholesale trade; Retail trade; Accommodation and food services; Transport, postal and warehousing; Information media and telecommunications; Financial and insurance services; Arts and recreation services; Rental, hiring and real estate services; Professional, scientific and technical services; Administrative and support services; Other services; Public administration and safety; Education and training; and Health care and social assistance.

is the sum of sectoral productivity growth weighted by sectoral GDP share. The latter is the change in productivity from sectoral reallocation of workers (see Appendix B for methodology).[10]

Within-sector labour productivity growth

In the absence of workers moving between sectors, it is the productivity growth within sectors that determines growth in aggregate labour productivity. Chart 2 shows how labour productivity has grown in different sectors.

Chart 2: Sectoral labour productivity (indexed to 1988-89)



Source: ABS cat. no. 5204.0 (Table 5, Table 15), ABS cat. no. 5260.0.55.002 (Table 6), ABS cat. no. 6291.0.55.003 (Table 11, supplemented with unpublished ABS data) and Treasury calculations.

A few initial observations can be made from Chart 2:

- Labour productivity has grown strongly in the Agriculture, Forestry and Fishing sector, with productivity in the sector now over 2½ times its 1988-89 level.
- The Mining and Utilities sectors showed strong labour productivity growth until the early 2000s before steadily declining through to 2011-12.[11] In fact, Mining sector productivity fell so far over the period that in 2011-12 it was below its 1988-89 levels.[12]

10 The shift share-analysis considered in this article can be used to shed light on whether resource reallocations between industries are producing efficiency gains through higher productivity outcomes or whether developments within industries are driving aggregate productivity outcomes. The analysis is primarily concerned with describing where, on an industry basis, productivity growth is coming from. The analysis says nothing about the underlying factors driving resource allocation between industries or the nature of developments within industries.

11 The productivity decline in the Utilities sector from 1997-98 was due to its own unique set of factors. The construction of new facilities for the provision of water services, the higher levels of investment to replace ageing network infrastructure, the move from large coal to gas-fired power stations and renewable energy sources which require higher inputs per unit of output and the drought affecting output levels in water in the early 2000s all detracted from productivity growth in the sector (Productivity Commission, 2012a and 2012b).

12 The reduction in the level of labour productivity in the Mining industry during the 2000s can be explained by the lead times between capital investment and the corresponding increase in output, the employment of less skilled workers at the outset of the mining boom and the depletion of high quality natural resources. In interpreting Mining sector productivity it should be noted the dramatic fall in Mining productivity in the 2000s may also reflect some Construction sector labour being misclassified as Mining sector labour.

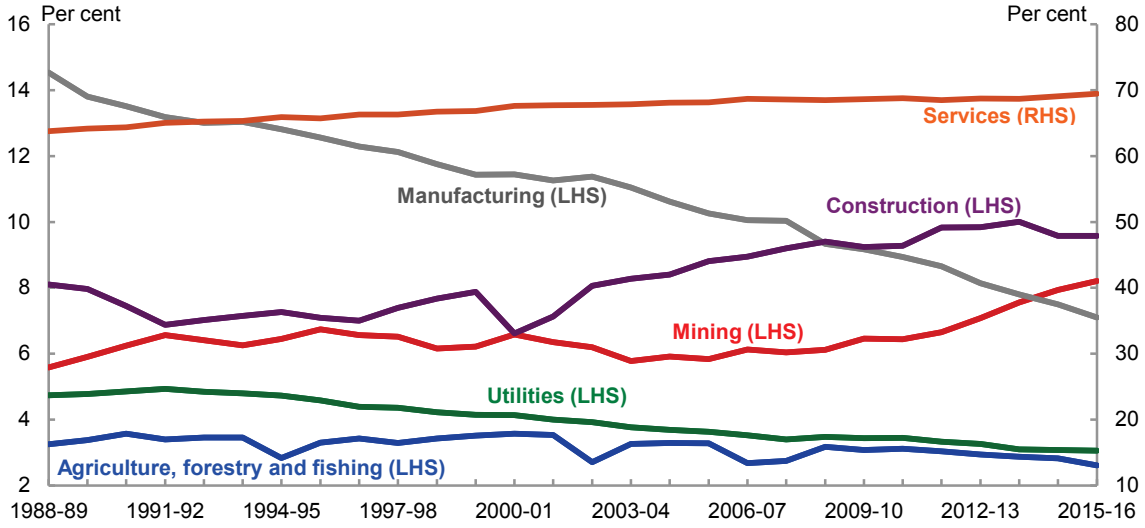
  - Recent data show that with the shift of the mining boom to the production phase, Mining sector labour productivity growth has improved. Despite more subdued productivity growth in Mining during 2015-16, the sector's productivity growth is expected to continue its recovery in coming years as output increases (the payoff to the capital deepening from 2003-04 seen in Chart 1).

- Productivity in the Manufacturing and Construction sectors has shown growth consistent with that of the broader economy.

- Similarly, labour productivity in Australia's services sectors over the past 25 years has grown at an average annual rate of 1.7 per cent — broadly in line with long-run labour productivity growth for the whole economy.

  - This result is not surprising, given the services sectors we define collectively account for almost 70 per cent of Australia's economic output (sector shares of output are shown below in Chart 3 — note that the services sectors are plotted against the right-hand-side axis).[13]

Chart 3: Sector shares of total economic output (gross value added)



Source: ABS cat. no. 5204.0 (Table 5).

Chart 3 demonstrates that despite the attention given to Mining as a determinant of Australia's productivity performance, it is the services sectors that will continue to play a key role in driving future aggregate productivity growth. Mining's share of output is certainly significant — now over 8 per cent of the economy, rising sharply from just over 5½ per cent in 2003-04. But over the last five years over half of Australia's annual aggregate labour productivity growth was attributable to growth within the services sectors, compared with around one-quarter attributable to Mining. This underlines the importance of policy settings in the services sectors.

Meanwhile, Manufacturing and Agriculture (often referred to as key drivers of Australia's productivity) continue to shrink. The two industries now contribute less than 10 per cent of

13 It should also be noted that within the services sector composite the individual productivity levels and growth rates of individual services sectors differ greatly; some suggest this makes them inappropriate to consider in aggregate (Inklaar, Timmer and van Ark, 2007). While analysis of individual services sectors is beyond the scope of this paper (perceptions about poor productivity performance in the services sectors could relate to individual sectors) they have been aggregated to demonstrate their size and historical contribution to aggregate growth.

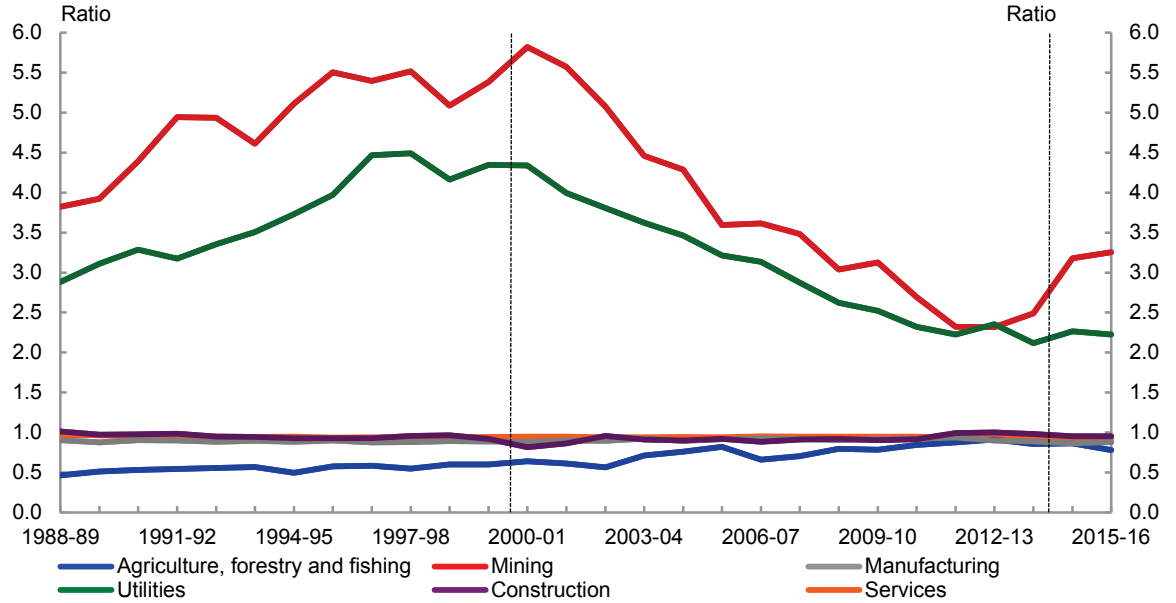
Australia's output combined (around 7 per cent and 2½ per cent respectively). Their contribution to aggregate productivity growth over the last five years has been negligible.

Structural change

Structural change involves the shift of resources from one industry to another. As workers shift in this way, the contribution to aggregate labour productivity growth will depend on the relative productivity between sectors. For instance, workers moving from relatively high productivity sectors to relatively low productivity sectors will detract from aggregate productivity growth (and vice versa).

In this respect, the key sector is Mining. Although the level of productivity in the Mining sector over recent decades has been far from consistent, it has remained the highest in the Australian economy. Among the sectors featured in Chart 4, only the productivity levels of the Utilities sector have come close to the levels of the Mining sector in this period. The Mining sector is currently recording productivity that is over three times the economy wide average in 2015-16 (after peaking at almost six times the economy wide average in 2000-01).

Chart 4: Sectoral labour productivity levels (relative to economy-wide average)

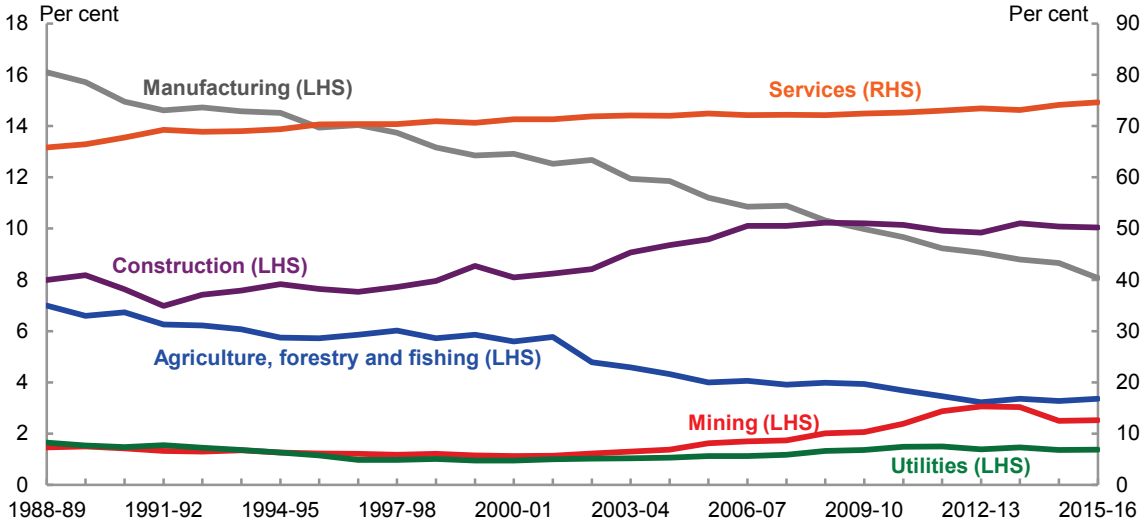


Source: ABS cat. no. 5204.0 (Table 5), ABS cat. no. 6291.0.55.003 (Table 11, supplemented with unpublished ABS data) and Treasury calculations.

As such, structural change will only have a significant effect on aggregate labour productivity growth when labour moves in and out of the Mining sector (and to a slightly lesser extent, the Utilities sector). As Chart 4 shows, there is little gain or cost to aggregate labour productivity growth when labour moves between sectors with similar productivity levels, such as Manufacturing, Construction and Services.

In some sectors, there has been an inverse relationship between productivity growth and labour share. Chart 5 below shows how each sector's share of hours worked has changed since 1988-89, thereby highlighting the movement of labour across sectors (again, note that the services sectors are plotted against the right-hand-side axis). The strong labour productivity growth in Agriculture over recent decades shown in Chart 2 is explained by the sector experiencing reduced hours worked (Chart 5) for the production of broadly the same output (Chart 3).

Chart 5: Hours worked share



Source: ABS cat. no. 6291.0.55.003 (Table 11, supplemented with unpublished ABS data) and Treasury calculations.

The same inverse relationship is evident in the Mining sector — with significant ramifications for aggregate productivity growth. The decline in the share of hours worked in the Mining and Utilities sectors from 1988-89 to the early 2000s is associated with rising productivity levels illustrated in Chart 2 and Chart 4. This inverse relationship, particularly in Mining, then continued albeit in the other direction as the Mining boom attracted labour while productivity fell sharply (due to a combination of a significant increase in labour with a modest increase in output). This is now beginning to turn around again. These movements of labour into and out of Mining have been the key driver behind the fluctuations in both the within and across sector contributions to aggregate labour productivity growth.

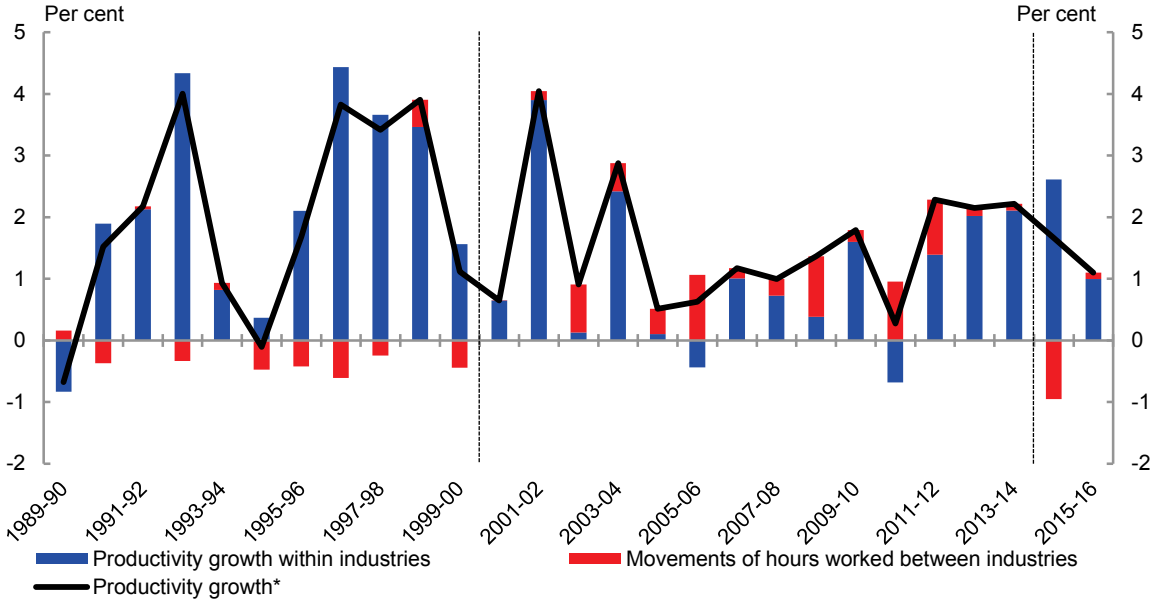
Overall contributions to aggregate productivity growth

To understand the relative contributions of each to aggregate productivity growth, Chart 6 below decomposes it into contributions from within-sector growth and the reallocation of workers across sectors. In doing so, it illustrates distinct periods where sector reallocation has detracted from aggregate labour productivity growth and where it has contributed to it.[14]

The chart shows that productivity growth is largely driven by the within-sector contribution. Looking across the whole sample, just over 90 per cent of the economy's aggregate labour productivity growth has come from within-sector productivity growth. In other words, the effects of structural change, including the ups and downs of the Mining boom, has contributed less than 10 per cent of the economy's aggregate labour productivity growth since 1988-89.

14 The red bars of Chart 6 are closely related to movements of the Mining sector's share of hours worked in the economy in Chart 5. That is, when Mining's share of hours worked falls (such as during the period from the early 1990s up until the turn of the century), we see large blue bars (strong within-sector productivity growth, largely driven by Mining's productivity performance) and smaller negative red bars (the offsetting effect on aggregate labour productivity growth of losing labour to less productive sectors). When the Mining sector's share of hours worked rise (such as from the early 2000s until recently), we see smaller blue bars combining with positive red bars as reduced productivity growth within Mining is supplemented by the positive effect of the sector attracting labour from lower productivity sectors like Agriculture and Manufacturing.

Chart 6: Labour productivity growth decomposed into within and across sector effects



Source: ABS cat. no. 5204.0 (Table 5), ABS cat. no. 6291.0.55.003 (Table 11, supplemented with unpublished ABS data) and Treasury calculations.
*There are slight differences in labour productivity aggregated growth rates using hours worked data in this figure and the indexed hours worked data reported in National Accounts.

A few episodes highlighted in Chart 6 are worth highlighting:

- The 1988-89 to 1999-00 period, represented by strong within-sector labour productivity growth partially offset by the loss of labour from high-productivity sectors (Mining and Utilities), bares similarities with 2014-15.

- The 1999-00 to 2013-14 period, represented by generally lower within-sector labour productivity growth supplemented by the addition of labour to high-productivity sectors, looks more like 2015-16.[15]

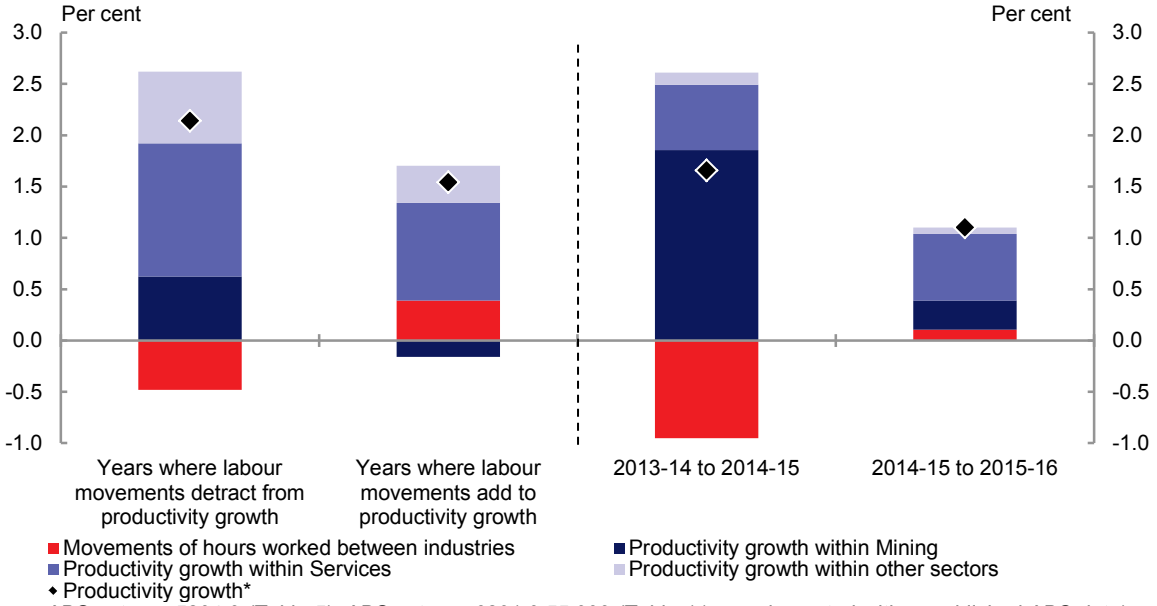
- The last two years, when taken together, reflect the recent declining trend in the share of Australia's labour force attached to the Mining sector while the services sector's labour share continues to grow, detracting from aggregate labour productivity growth.[16]

The above observations suggest likely future developments in Australia's productivity growth. Notwithstanding the slight return of labour to Mining in 2015-16 due to the relatively labour intensive LNG projects in Western Australia and Queensland, Mining's share of the labour force is expected to continue to fall across the following decade and provide a drag on aggregate labour productivity growth. But as output in the Mining sector continues to rise during the continuing production phase (see Chart 3) and labour moves elsewhere, we expect within-sector Mining productivity growth to more than offset the detraction to aggregate productivity growth from labour moving to less productive sectors (like services).

15 2015-16 saw a slight return of labour towards Mining.
16 It is worth noting that this reallocation of labour coincided with the end of the construction phase of the mining boom, so the combination of less labour needed and greater output from the production phase means that productivity within the sector is beginning to recover (Chart 4).

Chart 7 provides further insights into the relationship between labour movements into and out of the Mining sector and productivity growth within that sector. It reproduces Chart 6 but separates the years where movements of labour detract from aggregate productivity growth and where they add to it; and separately identifies the contribution to aggregate labour productivity growth of the Mining and services sectors.

Chart 7: Labour productivity for selected periods decomposed into within (by sector) and across sector effects



Source: ABS cat. no. 5204.0 (Table 5), ABS cat. no. 6291.0.55.003 (Table 11, supplemented with unpublished ABS data) and Treasury calculations.
*There are slight differences in labour productivity aggregated growth rates using hours worked data in this figure and the indexed hours worked data reported in National Accounts.

A striking feature of Chart 7 is that when labour movements have detracted from aggregate productivity growth (the first and third columns), aggregate productivity growth in those years (the black marker) has been higher than years where labour movements have made a positive contribution (the second and fourth columns). This means, essentially, that the within-sector effect from Mining when labour leaves the sector dominates the across-sector effect. When labour moves towards Mining, within-sector productivity growth in Mining is significantly weaker.

The longer-term samples of the first two columns of Chart 7 also highlight the significant role that the services sectors have played in underpinning aggregate labour productivity growth over almost three decades.

While no clear pattern emerges from recent years to help predict what the next few years may look like, we expect the foreseeable future to look more like the first and third columns, with quite strong aggregate labour productivity growth. A risk to this prediction, which is evident in 2015-16, is the possibility that additional labour will be used to take advantage of the temporary spikes in resources prices in the shorter term, which would lead to more columns like the fourth column.[17]

17 At the 2017-18 Budget, the assumed price for Australia's key commodities exports were: iron ore at US$66/tonne; metallurgical coal at US$200/tonne; thermal coal at US$85/tonne.

Regardless, the Mining sector is expected to continue to be a significant contributor to aggregate labour productivity growth in coming years. For example, despite the Mining sector actually adding labour in 2015-16 — which contributed to labour productivity growth in the sector falling from 29.5 per cent in 2014-15 to 3.4 per cent in 2015-16 — within sector Mining productivity growth still contributed around a quarter of the economy's aggregate labour productivity growth (column 4 of Chart 7).

Conclusion

Despite concerns about Australia's labour productivity and MFP growth in light of the lower terms of trade and an ageing population, recent labour productivity growth (driven by capital deepening) is in line with its longer-term averages.

In addition, there is little cause for alarm over the effect of structural change on productivity growth. While the services sectors continue to attract more and more labour, their aggregate productivity level is similar to all other sectors of the economy bar Mining and Utilities and their combined within-sector productivity growth is tracking at similar speeds to that of the whole economy (in part as they already represent over two-thirds of the economy). Indeed, it is labour productivity growth in the services sectors that has been underpinning aggregate productivity growth in Australia over recent decades, and will continue to do so, notwithstanding cyclical periods of weak and strong productivity growth in the Mining sector (which is largely associated with inflows and outflows of workers in the sector) or other sectors.

While the Mining sector is expected to continue to make a strong contribution to Australia's productivity growth in the next few years, the services sectors will remain responsible for growth prospects in the longer term. With within-sector productivity growth the dominant force behind aggregate productivity growth, both capital deepening and MFP improvements will be important to support future growth in labour productivity in Australia.

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Appendix A

Data

This article uses two different sources of Australian Bureau of Statistics (ABS) hours worked data to calculate labour input. Index data is sourced from the National Accounts (ABS cat. no. 5204.0) and Multifactor Productivity (ABS cat. no. 5260.0.55.002) data releases and is typically used for official productivity reporting. Levels data is sourced from the Labour Force Statistics (ABS cat. no. 6291.0.55.003) and is required for the analysis of movements of labour.

Using these sources, aggregate labour productivity estimates for the 12 industry market sector, the 16 industry market sector and the whole economy are available from 1973-74, 1994-95 and 1977-78 respectively.

Sectoral productivity analysis requires levels data from the ABS Labour Force Statistics. There are slight differences between estimates of growth in hours worked using levels data and the index data used elsewhere in the paper — particularly when comparing whole of economy and disaggregated industry sector data — which lead to differences in labour productivity estimates for a given increase in real GDP.[18]

While improvements in labour quality, for example through education and training, can be a source of productivity gains, for simplicity this article uses an hours worked basis when considering labour input (as opposed to quality adjusted hours worked).

Industry classification

The economy comprises market and non-market industries, listed with their availabilities in Table 1 below. The market sector industries are broken up into the 12 industry market sector industries and four 'new' services industries, included since 1994-95.

18 The levels data are stock data (referring to a particular week within the quarter) and will therefore not sum to the ABS headline figures used in the National Accounts (which is based on flow data that covers the entire quarter).

Table 1: Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06)

'12 industry market sector' industries	**'New' services industries**	**Non-market industries**
Industry data from 1988-89	*Industry data from 1994-95*[19]	*Industry data from 1994-95*[20]
Agriculture, Forestry and Fishing	Rental, Hiring and Real Estate Services	Public Administration and Safety
Mining	Professional, Scientific and Technical Services	Education and Training
Manufacturing	Administrative and Support Services	Health Care and Social Assistance
Electricity, Gas, Water and Waste Services	Other Services	Ownership of Dwellings
Construction		
Wholesale Trade		
Retail Trade		
Accommodation and Food Services		
Transport, Postal and Warehousing		
Information, Media and Telecommunications		
Financial and Insurance Services		
Arts and Recreation Services		

19 While data from the 'new' services industries is available as part of the '16 industry market sector' from 1994-95, output and employment data for these industries can be obtained from 1988-89 to create the composite 'services sectors' series from 1988-89 used in this article.

20 MFP and capital deepening components are unavailable for these industries.

Appendix B

We thank Michael Kouparitsas and Daniel Silva-Withmory for providing the following analysis.

Shift-share analysis

Aggregate labour productivity is the ratio of total gross value added to the number of hours worked in the economy; equal to the sum of labour productivity levels in each sector weighted by the hours worked in those sectors. Growth (or decline) in labour productivity can therefore be attributed to either changes in productivity levels in individual sectors or changes in employment share in each industry.

This decomposition of aggregate labour productivity growth is shown below, by letting Y be aggregate output and Y_i be sectoral output, N be aggregate hours worked and N_i be sectoral hours worked.

Output at time t is the sum of sectoral output Y_{it}:

$$Y_t = \sum_i Y_{it}$$

Which we can divide through by hours worked for productivity:

$$\frac{Y_t}{N_t} = \sum_i \frac{Y_t}{N_{it}} \frac{N_{it}}{N_t}$$

Subtracting by previous period for the change in productivity;

$$\frac{Y_t}{N_t} - \frac{Y_{t-1}}{N_{t-1}} = \sum_i \frac{Y_{it}}{N_{it}} \frac{N_{it}}{N_t} + \sum_i \frac{Y_{it-1}}{N_{it-1}} \frac{N_{it-1}}{N_{t-1}}$$

And rearranging:

$$\frac{Y_t}{N_t} - \frac{Y_{t-1}}{N_{t-1}} = \sum_i \left(\frac{Y_{it}}{N_{it}} - \frac{Y_{it-1}}{N_{it-1}}\right) \frac{N_{it}}{N_t} + \sum_i \left(\frac{N_{it}}{N_t} - \frac{N_{it-1}}{N_{t-1}}\right) \frac{Y_{it-1}}{N_{t-1}}$$

Which we can divide through by lagged productivity the aggregate for growth rate:

$$\frac{\left(\frac{Y_t}{N_t} - \frac{Y_{t-1}}{N_{t-1}}\right)}{\frac{Y_{t-1}}{N_{t-1}}} = \sum_i \frac{\left(\frac{Y_{it}}{N_{it}} - \frac{Y_{it-1}}{N_{it-1}}\right) \frac{N_{it}}{N_t}}{\frac{Y_{t-1}}{N_{t-1}}} + \sum_i \frac{\left(\frac{N_{it}}{N_t} - \frac{N_{it-1}}{N_{t-1}}\right) \frac{Y_{it-1}}{N_{t-1}}}{\frac{Y_{t-1}}{N_{t-1}}}$$

And rearranging to express the growth rate of productivity as its contributions from within industry productivity improvements and reallocations of labour.

$$= \sum_i \frac{\left[\left(\frac{Y_{it}}{N_{it}} - \frac{Y_{it-1}}{N_{it-1}}\right) \frac{N_{it}}{N_t}\right] \frac{Y_{it-1}}{N_{it-1}}}{\frac{Y_{it-1}}{N_{it-1}}} \frac{Y_{t-1}}{N_{t-1}} + \sum_i \left(\frac{N_{it}}{N_t} - \frac{N_{it-1}}{N_{t-1}}\right) \frac{\frac{Y_{it-1}}{N_{it-1}}}{\frac{Y_{t-1}}{N_{t-1}}}$$

$$= \sum_i \frac{\left(\frac{Y_{it}}{N_{it}} - \frac{Y_{it-1}}{N_{it-1}}\right)}{\frac{Y_{it-1}}{N_{it-1}}} \frac{Y_{it-1}}{Y_{t-1}} \frac{N_{it}}{N_t} \frac{N_{t-1}}{N_{it-1}} + \sum_i \left(\frac{N_{it}}{N_t} - \frac{N_{it-1}}{N_{t-1}}\right) \frac{\frac{Y_{it-1}}{N_{it-1}}}{\frac{Y_{t-1}}{N_{t-1}}}$$

Given that:

$$\frac{N_{it}}{N_t}\frac{N_{t-1}}{N_{it-1}} \approx 1$$

It follows that:

$$\frac{\left(\frac{Y_t}{N_t}-\frac{Y_{t-1}}{N_{t-1}}\right)}{\frac{Y_{t-1}}{N_{t-1}}} \approx \underbrace{\sum_i \frac{\left(\frac{Y_{it}}{N_{it}}-\frac{Y_{it-1}}{N_{it-1}}\right)}{\frac{Y_{it-1}}{N_{it-1}}}\frac{Y_{it-1}}{Y_{t-1}}}_{(Within\ industry\ )} + \underbrace{\sum_i \left(\frac{N_{it}}{N_t}-\frac{N_{it-1}}{N_{t-1}}\right)\frac{\frac{Y_{it-1}}{N_{it-1}}}{\frac{Y_{t-1}}{N_{t-1}}}}_{(Across\ industry)}$$

The first term in the decomposition is the weighted sum of productivity growth within individual sectors, where weights are the share of output of each sector at the beginning of the time period — the 'within industry' component of productivity growth.

The second term captures the effect on aggregate productivity growth from the reallocation of labour across different sectors. This is a weighted sum of the changes in sectoral employment shares, where the weights are relative productivity levels at the beginning of the time period — the 'across industry' component of productivity growth.