

Australia's Productivity Growth Slump: Signs of Crisis, Adjustment or Both?	Visiting Researcher Paper
	April 2012
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ISBN 978-1-74037-393-7

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An appropriate citation for this paper is:

Parham, D. 2012, Australia's Productivity Growth Slump: Signs of Crisis, Adjustment or Both?, Visiting Researcher Paper, Productivity Commission, Canberra.

JEL code: D

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Visiting Researcher papers

This publication is the third in an occasional series presenting the work of visiting researchers at the Productivity Commission.

In support of its core function of conducting public inquiries and studies commissioned by the Government on key policy and regulatory issues, the Commission conducts supporting research into diverse issues concerning productivity and its determinants, environmental and resource management, labour markets, and economic models and frameworks to aid policy analysis.

To assist the research effort, the Visiting Researcher Program seeks to attract established researchers in areas closely related to the Commission's primary research themes. Visiting researchers share their expertise and knowledge with Commission staff and contribute to the work of the Commission during appointments which are usually for terms up to one year.

During their stay with the Commission, visiting researchers take an active interest in the work of the Commission and mentor its staff. It is common for visiting researchers not only to conduct their own research in conjunction with Commission staff but also to contribute to the research work of others in their areas of expertise. However, *the views expressed in this series are those of the visiting researchers themselves, and do not necessarily represent those of the Commission*.

More details on the Visiting Researcher Program and released papers are available on the Commission's website at www.pc.gov.au/ research.

Preface

This paper examines the sources of the decline in Australia's productivity growth since the record highs of the 1990s, focusing on the last two complete productivity cycles (ending in 2007-08). It offers a different perspective by looking for a general or macro-economic explanation and then tracing the origins to specific industries. It identifies quite specific and comprehensive industry contributions to the aggregate productivity growth slump. Reasons for changes in industry productivity contributions are then drawn from other studies. Some areas for further research are indicated.

Don Brunker, Jenny Gordon and Mike Woods assisted in the development of the research. The Australian Bureau of Statistics, and specifically Derek Burnell and Pengfei Zhao, provided very valuable assistance with data and methodological issues.

Helpful comments on an earlier draft were also received from Ellis Connolly and Pat D'Arcy from the Reserve Bank of Australia and from Paula Barnes, Cindy Li, Leo Soames and Shiji Zhao from the Productivity Commission.

Dean Parham was a part-time Visiting Researcher at the Productivity Commission from February to December 2011 when the research for this paper was undertaken. Until 2008, he was an Assistant Commissioner at the Commission, where he led a team engaged in research on Australia's productivity.

1 Introduction and summary

1.1 Background

At face value, Australia's productivity growth would seem to have completely disappeared. After a record-high rate in the 1990s, growth in multifactor productivity (MFP) slumped in two steps of equal size, first to a more typical rate, and then to zero in the mid- to late-2000s (figure 1.1). In fact, according to the official 'headline' series published by the ABS, productivity actually went backwards.¹

Figure 1.1 Australia's multifactor productivity growth over productivity cycles^a



per cent per year

^a In the 12-industry market sector. *Data source*: ABS (2011a).

¹ Figure 1.1 uses ABS data for the 12-industry market sector. In the ABS official 'headline' series, which is for the 16-industry market sector, MFP growth was -0.5 per cent a year over 2003-04 to 2007-08. The 12-industry series is used in this paper because of the longer time series available and because of some concerns, shared by the ABS, about the quality of estimates for the additional industries in the 16-industry series (ABS 2011b).

The high productivity growth of the 1990s brought home two key messages. First, productivity growth matters as a source of prosperity for Australians. Second, the policy environment is important for fostering productivity growth. Specifically, the 1990s productivity surge is now widely seen as a dividend from economic reforms introduced over the 1980s and 1990s (Parham 2004).

It is perhaps not surprising then that there has been widespread concern about the subsequent slump in productivity growth and its relationship to reform momentum. Garnaut (2005), for example, bemoaned the 'reform complacency' that had set in and the lack of genuine reforms since the introduction of the GST in 2000.

Without seeking a comprehensive explanation for the slump, the Productivity Commission (PC 2009; PC 2010) highlighted some extraneous (non-reform) factors that accounted for its depth — the effect of drought on agriculture (by reducing output growth), the effect of a dramatic increase in commodity prices on mining (by, for example, making it worthwhile to expend more extraction effort on lower quality deposits, which means using more inputs per tonne of output) and the effect of drought and shifts in demand and technology on the utilities sector (by limiting output growth while increasing input growth).

Dolman (2009) looked for a comprehensive set of explanations in a comparison of the 1990s and the 2000s productivity performances. He noted some slowdown in the pace of productivity-enhancing reforms in the 2000s, but also judged that most of the gains from trimming workforces and improving utilisation of existing capacity had run their course. However, he gave greater weight to a new set of influences in the 2000s: the developments in mining and drought's effect on agriculture that the Productivity Commission had identified; the possibility that opportunities for productivity growth had slowed worldwide in the 2000s; and the growth in profits that may have slowed productivity momentum by allowing lessefficient firms to remain in operation for longer and by perhaps reducing the imperatives on other firms to reduce costs. Finally, he noted that important factors underpinning productivity growth over the long term and specifically in the 1990s - investment in ICTs, education and skills, R&D activity and infrastructure spending — had not diminished in the 2000s. This further reinforces the notion that there was a new set of influences at work in reducing productivity growth in the 2000s.

Nevertheless, concern about the productivity slump and its sources remains. For example, Saul Eslake (Eslake and Walsh 2011; Eslake 2011) has contended that the productivity slowdown is widespread among industries and has attributed the slowdown in large part to a lack of momentum on productivity-enhancing reforms and the introduction of some productivity-reducing measures.

2 AUSTRALIA'S PRODUCTIVITY GROWTH SLUMP Viewed from a few steps back, the debate about Australia's productivity slump seems to have overlooked the significance of the depth to which the rate of productivity growth has fallen. Multifactor productivity (MFP) growth over the most recent productivity cycle was at an unprecedented low. More than that, it was zero (or even negative!).

A zero (or negative) rate of MFP growth is significant for two reasons.

First, the *extent* of the productivity slump could not be a simple case of the positive influences of the 1990s petering out, or even being wound back, in the 2000s. A return to 'normal' productivity growth (perhaps somewhere around the long-term average) might be expected in that case. At worst, it might return to some 'pre-reform' rate but, unless opportunities for productivity growth have disappeared, even this would be an unlikely scenario. The factors (such as more efficient capital markets and fewer impediments to competition) that promote ongoing efficiency improvement in the economy are much stronger now than they were two or three decades ago. For productivity growth to descend to a record-low rate some other new developments must have come into play.

Second, to descend to a zero or negative rate of MFP growth over a complete productivity cycle suggests that something very unusual was happening on a large scale. A zero or negative rate of MFP growth looks suspicious because, at face value, it implies that there has been no advance in technical knowledge and innovation, and no improvement in the economy's operational efficiency. This would not make a lot of sense.

When there is a suspiciously-low (or negative) rate of MFP growth, productivity analysts call on four 'usual suspects' — policy aside — to explain it:

- volatility and cyclical effects
 - productivity can decline when there is a temporary downturn in the production of outputs or if there is a build-up of capital due to 'lumpy' investment cycles;
- compositional shifts
 - to the extent that productivity levels differ across industries (and firms), shifts in the relative size of industries (and firms) toward those with relatively low measured productivity would reduce aggregate productivity;
- adjustment pressures
 - some change in the economic environment induces responses among producers that require a period of investment in new capital (physical,

intangible and human) and this leads to greater use of inputs in the adjustment period, without a matching output response;

- measurement error
 - some 'true' growth in output (such as through quality improvements) can remain unrecorded.

The key point is that, to the extent that such explanations are at work, a drop in measured productivity growth does not represent a prosperity-sapping misallocation of resources or loss of knowledge or efficiency.

Because Australia's productivity growth has slumped so low, it is very probable if not certain — that the 'usual suspects' have been at work. This does not mean that they explain the entire slump. But, to the extent that they do provide some explanation, the slump would represent less of a crisis than it first appears.

1.2 What the paper does and says

The paper does three main things.

It first seeks a general or 'macro' explanation for the productivity slump in proximate terms — that is, in terms of the relative growth in inputs and outputs.

Second, it explores the contributions of individual industries to the aggregate trends. It sets out a new methodology that measures industry contributions comprehensively and accurately (aside from any quirks in the data).

Third, it seeks deeper explanations for industry input, output and productivity trends. The ultimate objective is to determine the extent to which Australia's productivity growth slump reflects factors of little consequence for efficiency or the prosperity of Australians relative to genuine 'loss of efficiency'.

Before going any further, some nomenclature and data conventions should be clarified. In the paper, the term 'productivity' always refers to multifactor productivity (MFP), unless explicitly stated as otherwise. (MFP is a measure of how well both labour and capital are combined to generate output.) Output refers to value added and inputs refer to capital services and labour (hours worked). As noted, for data continuity and reliability reasons, MFP estimates are drawn from the ABS series for the 12-industry market sector, rather than the 16-industry market sector now used as the 'headline' national accounts measure. 'The 2000s' refers to the first decade of the 21st century. The data series used include the major revisions to the national accounts published by the ABS in December 2011 (ABS 2011a).

⁴ AUSTRALIA'S PRODUCTIVITY GROWTH SLUMP

The big picture

The next chapter explores the proximate reasons for the productivity decline. This reveals the dominant new development of the 2000s — the acceleration in input growth to a record high. This mostly involved capital growth, although there was also healthy growth in labour.

At the same time, output growth remained largely unchanged. And so, in proximate terms, the decline in MFP growth was associated with 'unrequited input growth' — strong acceleration in input demand that was not matched (or stimulated) by an acceleration in output growth.

This is the key to understanding Australia's much poorer productivity growth. Explanations must tell us why Australian businesses used a lot more inputs, without getting more growth in output.

This requirement again rules out 'reform fatigue' as a dominant explanation for the productivity slump. Why would businesses respond to reform fatigue by investing and employing more, but not expect an output dividend?

The notion of unrequited input acceleration does raise the question of how such a phenomenon could be sustained. Typically, output growth provides the additional income needed to fund additional growth in inputs. Consequently, unrequited input growth does not make financial sense, unless there is another source of income growth.

Chapter 2 also shows that profitability not only held up, but actually increased in the 2000s. The extra input accumulation was fuelled at least in part by increased profits and profit expectations. Clearly, productivity was not the source of growth in output and income that it was in the 1990s. Rather, the broad productivity trends of the 2000s seem to have been more the outcome of strong input growth driven by marked changes in prices and profits.

Industry contributions

Chapter 3 looks into the industry sources of the rapid acceleration in input use and assesses the extent to which mismatches in input accumulation and output growth at the industry level translated into contributions to slower aggregate MFP growth.

This is where the new methodology to provide a precise and comprehensive set of estimates of industry contributions to aggregate MFP growth comes into use. The methodology also enables industry MFP contributions to be decomposed further

into output, total input, capital and labour effects. The methodology, set out in appendix A, circumvents an 'aggregation problem' usually found in attempting to relate industry MFP estimates to aggregate MFP estimates.

Most of the industries that were faster accumulators of inputs in the latest cycle (compared with the previous cycle) contributed to the second phase of the MFP growth slump (over the two most recent cycles). Table 1.1 provides a summary.

	,				
	Input accumulation of	contributions	MFP growth contribution		
	рр	%	рр	%	
Mining	0.69	39	-0.42	37	
Manufacturing	0.30	17	-0.52	46	
Construction	0.23	13	0.04	-3	
Transport	0.18	10	-0.08	7	
Agriculture	0.17	9	-0.25	22	
Sub-total	1.6	88	-1.2	110	
Retail	0.09	5	-0.13	12	
Wholesale	0.08	4	-0.10	9	
EGWWS	0.07	4	-0.09	8	
Arts & rec	0.07	4	-0.06	6	
Sub-total	0.3	18	-0.4	35	
Financial &					
insurance	-0.01	-1	0.44	-39	
Telecommunications	-0.04	-2	0.05	-5	
Accom & food	-0.05	-3	0.00	0	
Sub-total	-0.1	-5	0.5	-45	
Market sector	1.8	100	-1.1	100	

Table 1.1Industry contributions to input accumulation and MFP
(between the 1998-99 to 2003-04 and 2003-04 to 2007-08
cycles)a

^a The contributions of the industries experiencing an MFP decline sums to greater than 100 per cent of the slump. Industries that experienced stronger MFP growth made a negative contribution to the slump, which brings the all-industries total back to 100 per cent.

Source: See chapter 3

Unsurprisingly, Mining made by far the biggest contribution (40 per cent) to the additional input accumulation in the last cycle, mostly through additional investment in capital but also through additional use of labour. Mining contributed 0.4 of a percentage point to (or nearly 40 per cent of) the 1.1 percentage point slump

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in productivity growth over the two most recent cycles.² The scale of the investment boom was so large that additional capital in Mining, considered in isolation, accounted for a 0.6 of a percentage point decline in market sector MFP growth.³

Manufacturing was next, accounting for 17 per cent of the additional growth in input use. However, the industry made the largest contribution of 0.5 of a percentage point to (or around 45 per cent of) the MFP growth slump. That contribution was so large because it was not just a matter of additional output growth falling short of additional input growth in this industry. Output growth fell in absolute terms over the two most recent productivity cycles.

Construction was the third largest contributor (13 per cent) to additional input growth. However, additional output growth in this sector was sufficient to offset the effect of its additional input use on market sector MFP growth. It made a slightly larger contribution to market sector MFP growth in the most-recent cycle.

Transport, postal & warehousing provided 10 per cent of the additional input growth. It made a 0.1 percentage point smaller contribution to aggregate productivity growth in the most recent cycle, compared with the previous cycle.

Agriculture contributed 9 per cent of the additional input growth. With a decline in output contribution as well, it reduced its MFP contribution by 0.3 of a percentage point.

There were smaller contributions to additional input growth from Retail trade, Wholesale trade, Electricity, gas, water & waste services (EGWWS) and Arts & recreational services. Each of these industries took 0.1 of a percentage point off their contributions to aggregate MFP growth.

Deeper reasons

Chapter 4 explores the deeper reasons for industries to have upped their input accumulation, without a commensurate increase in output growth, and therefore for them to have contributed to lower aggregate MFP growth. There are some important gaps in the explanations, as this paper relies on other studies rather than initiating

² The growth decompositions are not precise with respect to output growth in earlier years (for practical reasons that are not clear). As a result, there is a discrepancy in the total MFP deceleration (1.1 percentage points) in table 1.1, compared with published estimates of 1.2 percentage points.

³ Additional use of labour accounted for a further 0.1 of a percentage point, while additional output growth made a positive contribution of 0.3 of a percentage. That left Mining with the net -0.4 of a percentage point contribution mentioned in the text.

new ones. Lack of material on Manufacturing's contribution to the productivity growth slump is the largest gap.

A review of the reasons through the lens of the four 'usual suspects' then follows. In most cases, this merely requires mapping the industry explanations to the usualsuspect categories.

One further technical innovation in the paper lies in the realm of 'shift-share' analysis to investigate the aggregate productivity effects of compositional shifts — that is, the reallocation of production inputs between industries. Shift-share analysis essentially decomposes aggregate productivity growth into components of within-industry productivity growth (with a fixed industry mix) and between-industry shifts of production (with fixed *levels* of industry productivity). The analysis is typically applied to labour productivity measures, where the level of productivity is uniquely determined from data on output and hours worked. MFP is not used because the level of MFP cannot be uniquely determined. Because MFP can only be measured in index form, the level of MFP in any year (and the computation of reallocation effects) depends on the base year selected. The method used in this paper, set out in appendix B, circumvents this problem.

The MFP compositional effects are mostly found to be small, in contrast to the findings from labour productivity calculations, where there are large differences across industries in productivity levels due to differences in capital intensity. The one example provided here is hardly definitive, but it raises a question of whether the use of labour productivity as the basis for analysis instead of MFP provides an overstated or even misleading indication of the productivity effects of resource reallocation.

Industry explanations

Mining and Manufacturing were among the largest contributors to the more rapid input accumulation and to the MFP growth slump.

Mining has ramped up its use of inputs in response to the much higher prices being paid for its outputs. There has not been the same growth in output for two reasons. First, there is a short to medium term effect in which capital inputs grow in a mine development phase ahead of mine completion and commencement of saleable production. Second, there may never be additional output growth to match the additional input growth as the additional mining capacity is generally being installed to extract commodities from deposits that are harder to work (less pure, further away, deeper and so on). While there are diminishing returns in terms of the

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volume of output produced, investment in additional capacity is made worthwhile by the increased *value* of production.

Unfortunately, not enough is known at this point to explain why Manufacturing upped its growth in inputs while output growth fell. It may have been the result of structural pressures within the industry — some segments increasing capacity in response to ripples from the mining boom, with other segments reducing output for other reasons or as an indirect result of the mining boom due to a higher exchange rate.

While Agriculture made a smaller contribution to faster input accumulation, it still made a sizeable contribution to the MFP growth slump. A fall in output due to drought is thought to be a major factor. The persistence of drought may have also contributed to the faster growth in inputs.

Input growth accelerated in EGWWS, without an acceleration in output growth, for a variety of reasons. These include new peak customer demands, ensuring security of supply, and meeting lower emission requirements and output standards. All of these required new capital investments, but did not translate into additional output growth.

Further work needs to be undertaken to identify the reasons for unrequited input accumulation in other industries.

Crisis, adjustment, or both?

The paper does not marshal all the evidence needed for a definitive statement on the overall significance of the 'usual suspects'. Nevertheless, a rough reckoning suggests that the usual suspects may have accounted for somewhere between a half and three-quarters of the drop in Australia's productivity growth over the two most-recent productivity cycles.

A large part of the productivity growth slump stemmed from adjustment pressures. These pressures have had negative effects on productivity growth that reflect 'an economy in transition' to a new *level* of productivity (see chapter 4). The transition has been stimulated by a new set of relative prices, most notably the shift in the terms of trade.

The negative effects of adjustment pressures on productivity growth will attenuate. 'Normal' rates of productivity growth can be expected to return, once the transitions to new productivity levels have run their course. In the case of mining, for example, once a desired capacity and production rate is reached (consistent with prevailing price and profit expectations), productivity growth will revert to being determined largely by the interplay of depletion of resource deposits, new discoveries and technological advances.

For the most part, these transitional effects are not of concern in terms of loss of efficiency or growth in prosperity. In the case of mining, there is a loss of productivity based on the volume of production, but increased prosperity based on the value of production. The only proviso is that there is no over-allocation of resources to mining or misallocation within it. Regulatory burdens aside, market forces and corporate governance arrangements provide generally strong disciplines for efficient investment decisions in this industry. However, investment in EGWWS is not subject solely to private decisions, but is influenced by government policy, regulation and provision. For these reasons, there cannot be the same in-principle confidence about the efficiency of the additional input accumulation in this industry.

Furthermore, to the extent that the favourable shift in the terms of trade has brought about a productivity decline (especially via mining), that decline does not bring the usual concern in terms of its effect on the prosperity of Australians. That is because the favourable shift in the terms of trade yields 'compensating' direct improvements in prosperity by enhancing the purchasing power of Australian incomes.

All things considered, it seems safe to say that Australia's productivity growth slump, at least to 2007-08, has had more to do with adjustment (factors that do not affect growth in prosperity) than it does 'crisis' (factors that do affect growth in prosperity).

This does *not* mean that other factors, such as failure to maintain or advance reforms, did not contribute to the decline in productivity growth. It is just that such factors cannot explain a decline in MFP growth of the order of 1.2 percentage points between the last two complete productivity cycles.

2 The big picture

This chapter examines the trends in input and output growth that have accompanied the MFP growth slump. It finds that a strong acceleration in the use of labour and capital inputs was the major new development in the 2000s. The fact that input use accelerated so strongly, while output growth remained static or weakened, is the proximate explanation for the productivity slump. But the conjunction of rising input demand and weaker output growth is, on the face of it, a puzzle. Explaining this puzzle is the key to understanding why MFP growth fell.

2.1 Proximate explanations

A first step in seeking explanations for the productivity growth slump is to examine 'proximate' explanations for the MFP growth trends. Proximate explanations are the movements in input and output growth that account for movements in MFP growth. The contrast with the 1990s decade helps to highlight what was different about the 2000s.

Output is defined as value added and the two inputs considered are capital and labour.

The 1990s: meeting stronger output growth with average input growth

In terms of proximate explanations, MFP growth was so strong in the 1990s because more rapid output growth was achieved with around normal input growth (figure 2.1). More precisely, a very rapid rate of output growth (5.0 per cent a year over the productivity cycle from 1993-94 to 1998-99), well above the long-term average of 3.1 per cent a year, was met with a rate of input growth (2.4 per cent a year) only slightly above the long-term average of 2.2 per cent a year.

Put succinctly, the record-high productivity growth was about meeting stronger output growth with typical input growth. It was not a matter of cutting back on inputs to meet typical output growth.

The productivity surge has been widely attributed in large part to the policy reforms of the 1980s and 1990s. As well as providing direct productivity gains, such as better utilisation of labour and capital, these reforms enabled firms to access productivity gains based on innovations around the use of information and communications technologies (ICTs).¹ The above proximate explanation for the productivity acceleration in the 1990s is consistent with this deeper, causal explanation.

The 2000s puzzle: unrequited acceleration in input use

The trends in the 2000s were distinctly different.

An acceleration in input use was a major new development. While there was little change in input growth rates in the first phase of the productivity growth slump, input growth rose to a record-high rate of 4.1 per cent a year in the most-recent cycle (figure 2.1). Greater use of capital formed the bulk of that input growth (figure 2.2). Capital services grew at an average annual rate of 6.2 per cent.² Since the productivity estimation methodology assumes capital services to be proportional to the productive capital stock, this rate of growth also applies to the capital stock. Consequently, the productive capital stock in the market sector grew by 27 per cent over just four years. Use of labour grew by 4.1 per cent a year or a total of 17 per cent over the cycle.

While input growth accelerated, output growth was largely unresponsive (figure 2.1).

The slump in productivity growth over the two most recent cycles was therefore associated with a conjunction of stronger input growth and static output growth.

Input growth accounted for all output growth in the latest cycle, consistent with zero MFP growth (figure 2.1). (That trend has continued to an even greater extent since the latest complete cycle. Input growth has more than accounted for all output growth since 2007-08 and MFP growth has turned negative.)

The combination of stronger input demand without stronger output growth over a sustained period is odd, just as a zero rate of MFP growth was described as odd in the previous chapter. Ordinarily, input growth is viewed as a derived demand, stemming from output growth. Or, to put it another way, because growth in output (value added) means the same growth in income, the deficiency between additional output and input growth in the 2000s seems, at face value, to imply that producers have stepped up investment in capital and employed more labour — at very high rates — but have not required a similar growth in income.

¹ See, for example, Tressel (2008).

² ABS (2011a) The long-term average growth in capital services is 4.3 per cent a year.

Figure 2.1 Output growth, decomposed into input growth and MFP growth, over productivity cycles^a per cent a year

6.0 5.0 output growth 4.0 input growth 3.0 MFP growth 2.0 1.0 0.0 1973-74 to 1981-82 to 1984-85 to 1988-89 to 1993-94 to 1998-99 to 2003-04 to 1981-82 1984-85 1988-89 1993-94 1998-99 2003-04 2007-08

a 12-industry market sector. *Data source*: ABS (2011a).

Figure 2.2 Input growth, decomposed into labour and capital contributions, over productivity cycles^a



per cent a year

a 12-industry market sector.

Data source: ABS (2011a).

The proximate explanation for the 2000s productivity performance could therefore be characterised as an 'unrequited acceleration in input use'. The rapid acceleration in inputs is unrequited in the sense that it was not met with the same step up in growth in output (and the income growth it would bring).

A different form of presentation

The input, output and MFP data are presented in an alternative time-series form in order to give clearer indications of the trends. The annual growth rates are derived from 'smoothed' data series, so that trends can be distinguished without interference from the year-to-year volatility in the original series.³

Figure 2.3, which shows growth in MFP, output and inputs, is the analogue of figure 2.1, and figure 2.4, which shows capital and labour contributions to total input growth, is the analogue of figure 2.2.

The same story can be told from the two forms of presentation. Like the productivity cycle estimates, the smoothed data show that MFP growth went to a record high in the mid-1990s when output growth accelerated but input growth stayed around its long-term average (figure 2.3). There was an acceleration in input use in the 2000s to well above the long-term average, while output growth fell back toward its long-term average. With this, MFP growth declined and eventually fell to zero, once input growth caught up to output growth. Capital was the main source of acceleration in input use (figure 2.4).⁴

The smoothed data confirm the strength of the input acceleration in the 2000s devoid of short-term or cyclical elements. The smoothed data also further illustrate just how much the input acceleration was due to increased use of capital. Based on the smoothed capital series, the market sector's productive capital stock increased by 63 per cent over the 2000s.

³ While the smoothed estimates provide clearer indications of turning points, it is not intended that the estimates be relied on as an alternative to the traditional productivity-cycle method of determining underlying rates of growth, as adopted by the ABS in the official productivity estimates. A Hodrick-Prescott filter was used to smooth the original series. See Barnes (2011) for a discussion of alternative filters.

⁴ The labour and capital contributions in figure 2.4 are smoothed annual contributions. The implicit income share weights do not necessarily sum to one, as they should. The size of the errors would be small and of no consequence for the purpose here.



0.5 0.0 -0.5

> 1976-77 1978-79

l974-75

Figure 2.3 Annual growth in smoothed market-sector^a output, inputs and MFP^b

a 12-industry market sector. **b** The original series have been smoothed with a Hodrick-Prescott filter (λ =100). *Data source*: ABS (2011a)

1990-91

1992-93 1994-95 1998-99

2000-01 2002-03

1996-97

2008-09

2010-11

2004-05

2006-07

1988-89

1984-85

1982-83

1980-81

1986-87

Figure 2.4 Annual contributions of smoothed capital services and hours worked to total input growth^{a,b}



a 12-industry market sector. **b** The original series have been smoothed with a Hodrick-Prescott filter (λ =100). *Data source*: ABS (2011a)

2.2 Fuelling the input accumulation

Unless businesses were consistently making a series of very poor decisions, which is very unlikely, there must have been another source of income apart from output growth to fuel the very strong additional input growth.

Increased profitability

The evidence is that profitability increased in the 2000s, despite the slowing in output growth. That is, there were important sources of income growth apart from output growth.

Figure 2.5 provides some broad evidence from industries in the market sector. It shows the ratio of corporate profits (before tax) to the net capital stock for 11 industries (Agriculture excluded) and a longer time-series for 7 industries (see footnote to figure 2.5). While the profitability measure has some shortcomings (proprietors are excluded and the capital stock concept is different from the productive capital stock used in the ABS productivity accounts), it nevertheless provides a clear indication that profitability increased substantially in the early 2000s and was maintained at a rate well beyond what would have been provided by output growth alone. As noted, output growth declined over the 2000s.

To anticipate the discussion in the next chapter, changes in relative prices (particularly in mining commodity prices) were a major source of increased profitability.

2.3 Summary

Faster input growth was the dominant new development of the 2000s. While there was also more use of labour, the faster input growth was predominantly a story of very rapid capital accumulation.

The slowdown in MFP growth and its fall to zero can be explained in proximate terms as an unrequited acceleration in input growth — that is, input growth unmet by the same output growth.

That input growth accelerated so rapidly, over such a long period and to such a high rate while output growth remained static is, at face value, a puzzle. But explaining the puzzle would also explain why productivity growth slumped to such an extent.

A source of income, apart from growth in productivity and output, was needed to fuel the uptake in inputs. The strong increase in profitability in the 2000s provides evidence that there was an alternative source. Chapter 4 provides further detail.





^a The 7 industries are Mining, Manufacturing, EGWWS, Construction, Wholesale, Retail and Accommodation. The 11 industries also include Transport, Telecommunications, Financial and Arts & recreation. *Source*: Author's calculations based on data from ABS (Cat. no. 5204.0).

3 Industry contributions

This chapter looks at the 2000s developments through an industry lens. The place to start, of course, is the industry sources of input growth and, especially, the acceleration in input use over the two most-recent productivity cycles. A further objective is to find out where additional output growth fell short of faster input growth at the industry level. This reveals the industry sources of the aggregate productivity growth decline.

3.1 Industry sources of input growth

The allocation of inputs is examined through measures of 'industry contributions' to market sector growth in inputs. Industry contributions measure the growth in inputs in an industry, weighted by the relative importance of that industry in the market sector (see appendix A). They therefore readily show the sources of the market sector growth in input use.

The industry data is available for three complete market sector productivity cycles over the 1990s and the 2000s. Cycle 1 refers to 1993-94 to 1998-99, cycle 2 to 1998-99 to 2003-04 and cycle 3 to 2003-04 to 2007-08.

Total inputs

While there was little change in the growth of inputs in the first phase of the productivity slump, there was a strong acceleration in the second phase. The growth in the use of inputs in the 12-industry market sector increased from an annual average rate of 2.3 per cent over the 1998-99 to 2003-04 cycle to a record high 4.1 per cent over the 2003-04 to 2007-08 cycle (table 3.1).

Table 3.1 shows the growth in industries' use of inputs and their contributions to market sector input growth during the three productivity cycles of the 1990s and 2000s.

The Mining industry stands out for the acceleration in its use of inputs in the last cycle. The very rapid growth in its use of inputs, at 8.4 per cent a year, accounted for around 0.9 of a percentage point (or one-fifth) of the 4.1 per cent a year growth

in market sector inputs. This growth and market sector contribution were much higher than in the previous cycle.

	•		•	•		
Industry	Growth rates (per cent per year)			Contributions (percentage points)		
	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08
Agriculture	0.2	-1.2	0.7	0.01	-0.15	0.02
Mining	3.3	2.2	8.4	0.26	0.16	0.85
Manufacturing	1.5	0.7	2.5	0.34	0.13	0.43
EGWWS	-0.1	3.6	5.8	0.03	0.14	0.21
Construction	3.1	3.8	5.4	0.30	0.40	0.63
Wholesale	1.2	2.0	3.0	0.10	0.16	0.24
Retail trade	2.5	3.1	4.0	0.24	0.32	0.42
Accom and food	3.6	2.3	1.8	0.21	0.14	0.09
Transport, post, warehsg	2.5	2.2	4.2	0.20	0.18	0.37
Info, media, Telecomms	4.9	4.9	4.5	0.30	0.30	0.27
Financial & insurance	2.8	3.4	3.8	0.31	0.43	0.42
Arts & recreational	5.5	2.7	5.9	0.09	0.05	0.12
Market sector ^b	2.4	2.3	4.1	2.4	2.3	4.1

Table 3.1Industry growth in total inputs and contributions to market
sectora growth in total inputs over productivity cycles

 a 12-industry market sector. b The market-sector growth rates on the left hand side of the table are as published by the ABS. The rates on the right hand side are the sums of the contributions as derived from the methodology set out in appendix A.

Source: Author's estimates based on ABS data (see appendix A).

Electricity, gas, water, and waste services (EGWWS) and Construction also had strong growth in inputs (over 5 per cent a year), but Construction's larger size meant it made a larger contribution to aggregate input growth (0.6 of a percentage point than did EGWWS (0.2 percentage points).

The more immediate focus, however, is on which industries contributed most to the *acceleration* in input use over the three cycles. The major faster input accumulators can be readily gleaned from figure 3.1, which shows the change in industry contributions between cycle 1 and cycle 2 and between cycle 2 and cycle 3.

Most industries increased their contributions to input growth in the third cycle. However, the major faster input accumulators were:

- Mining which contributed 0.7 percentage point (40 per cent) of the 1.8 percentage point increase in aggregate input use
- Manufacturing which contributed 0.3 percentage point (17 per cent); •
- Construction which contributed 0.2 percentage point (13 per cent);
- Transport which contributed 0.2 percentage point (10 per cent);
- Agriculture which contributed 0.2 percentage point (9 per cent).

Figure 3.1 Industry contributions to more rapid input accumulation over successive productivity cycles



percentage points

Source: Author's estimates based on ABS data (see appendix A).

There is a second group of industries that made smaller contributions (under 0.1 percentage points each) to the faster accumulation of inputs in the third cycle. This group comprises:

- Retail trade;
- Wholesale trade;
- EGWWS; and •
- Arts & recreational services.

In the first three cases, these industries started their build-up of inputs in the second cycle and did not just have a sudden jump in the last cycle. Construction also began its faster input accumulation in the second cycle. Its contribution to market sector input growth increased by 0.3 of a percentage point over the three cycles.

More rapid accumulation of capital

As noted in the last chapter, increased use of capital accounted for most of the additional growth in total inputs.

Annual market sector rates of growth in capital services ranged from 1.8 to 4.5 per cent in the 1990s and from 2.9 to 6.8 per cent in the 2000s. Growth in use of capital accelerated from an average 3.9 per cent a year in cycle 2 to 6.0 per cent a year in cycle 3 (table 3.2).

Industry	Growth rates (per cent per year)			Contributions (percentage points)		
	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08
Agriculture	0.4	0.1	1.6	0.03	0.01	0.10
Mining	5.2	2.2	8.0	0.66	0.31	1.59
Manufacturing	3.7	3.3	5.4	0.79	0.63	0.92
EGWWS	2.1	3.6	5.7	0.16	0.24	0.34
Construction	3.6	3.2	6.1	0.22	0.20	0.40
Wholesale	4.4	5.1	8.0	0.31	0.32	0.49
Retail trade	5.4	5.6	6.8	0.26	0.26	0.33
Accom and food	4.9	4.4	5.1	0.09	0.09	0.10
Transport, post, warehsg	2.2	4.0	6.1	0.16	0.30	0.47
Info, media, Telecomms	7.9	6.5	6.4	0.67	0.59	0.52
Financial & insurance	4.5	5.6	4.3	0.65	0.89	0.66
Arts & recreational	8.9	5.6	5.5	0.10	0.08	0.08
Market sector ^b	4.1	3.9	6.0	4.1	3.9	6.0

Table 3.2Industry growth in capital use and contributions to market
sectora growth in capital use over productivity cycles

^a 12-industry market sector. ^b The market-sector growth rates on the left hand side of the table are as published by the ABS. The rates on the right hand side are the sums of the contributions as derived from the methodology set out in appendix A.

Source: Author's estimates based on ABS data (see appendix A).

On a minor technical note, the observant reader may notice that the growth rates displayed for the market sector growth in capital services in table 3.2 differ slightly from the estimates published by the ABS and reported in the previous chapter. This is due to a different method of calculating growth rates. The method used in this

paper is based on taking differences in logged values (appendix A). The ABS, however, calculates compound annual average rates of growth in discrete terms.¹

The mining boom dominates

The investment boom in Mining has been the major development leading to the more rapid growth in market-sector capital. While the acceleration in use of capital was widespread across industries, no other industry comes near Mining's role in the faster accumulation of capital.

Mining increased its capital stock at an annual average rate of 8.0 per cent in the last cycle.² Partly because mining is relatively capital intensive, this growth had a large effect on the total capital stock. Mining contributed 1.6 percentage points (or 25 per cent) of the 6.0 per cent growth in market sector capital.

Figure 3.2 shows how Mining dominated the acceleration in use of capital over the two most-recent productivity cycles. It added 1.3 percentage points of the additional 2.1 percentage points in annual growth in market sector capital between the two cycles. That was 60 per cent of the increase in market-sector capital growth.

The sharp rise in Mining's contribution to the growth in the aggregate capital stock came after 2004-05 (figure 3.3). Its annual contribution rose from a range of 0.2 percentage points to 0.9 percentage points in the 1990s to a range of 0.1 percentage points to 2.7 percentage points in the 2000s.

¹ The 'log' method provides more precise estimates of industry contributions that can be more easily reconciled with aggregate growth estimates. The two methods produce very similar results, except when the measured growth is rapid.

² Because the flow of capital services is assumed to be proportional to the productive capital stock in place, it is possible to talk interchangeably of growth in capital services and the same growth in productive stock.





Source: Author's estimates based on ABS data (see appendix A).

Figure 3.3 Annual contributions of Mining and Manufacturing to growth in market-sector capital services^a percentage points



^a Years depicted are 12 month periods to 30 June.

Data source: ABS (Cat. no. 5260.0.55.002 and unpublished ABS data (see appendix A)).

Other industries also up their contributions

The other more rapid input accumulators all upped their growth in capital to some degree.

Manufacturing also holds a large proportion of the aggregate capital stock. Consequently, its 5.4 per cent a year growth in capital in the last cycle added the second largest contribution of 0.9 percentage points to market sector growth in capital (table 3.2). It upped its contribution by 0.3 of a percentage point between the last two cycles (figure 3.2), which meant it provided 15 per cent of the faster growth in market sector capital. That increase came from more consistent (less volatile) growth in the last cycle, rather than a growth 'spike' anything like that of Mining (figure 3.3). Unlike Mining, Manufacturing's contribution has tailed off markedly since the end of the productivity cycle in 2007-08 (figure 3.3).

Growth in use of labour

Growth in hours worked was fairly steady over the first two cycles, but lifted strongly from an annual average rate of 1.0 per cent in the second cycle to 2.5 per cent in the third cycle (table 3.3).

Construction featured in the build-up of labour in the third cycle. Mining had a faster rate of growth of nearly 10 per cent a year on average in that cycle, but from a comparatively low base. On the other hand, Construction labour growth of 5.2 per cent a year added 0.8 percentage points to growth in use of labour in the market sector. This contribution was up by nearly three-tenths of a percentage point on the second cycle and nearly half a percentage point on the first cycle. (It was noted in the previous sub-section that Construction began its build-up of inputs in the second cycle.)

Industry	Growth rates (per cent per year)			Contributions (percentage points)		
	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08
Agriculture	0.0	-3.3	-0.6	0.00	-0.27	-0.05
Mining	-1.3	2.1	9.8	-0.03	0.04	0.25
Manufacturing	0.0	-1.2	0.2	0.01	-0.25	0.04
EGWWS	-4.1	3.4	5.9	-0.07	0.05	0.11
Construction	3.0	4.1	5.2	0.36	0.55	0.82
Wholesale	-0.6	0.5	0.5	-0.04	0.04	0.04
Retail trade	1.6	2.4	3.0	0.23	0.37	0.48
Accom and food	3.4	1.8	0.9	0.30	0.17	0.08
Transport, post, warehsg	2.6	1.1	3.0	0.23	0.10	0.28
Info, media, Telecomms	0.8	2.3	1.4	0.03	0.09	0.06
Financial & insurance	1.1	1.4	3.5	0.06	0.09	0.22
Arts & recreational	4.2	1.1	6.1	0.09	0.02	0.15
Market sector ^b	1.2	1.0	2.5	1.2	1.0	2.5

Table 3.3Industry growth in hours worked and contributions to
market sectora growth in hours worked over productivity
cycles

 a 12-industry market sector. b The market-sector growth rates on the left hand side of the table are as published by the ABS. The rates on the right hand side are the sums of contributions derived from the methodology set out in appendix A.

Source: Author's estimates based on ABS data (see appendix A).

Figure 3.4 shows that Manufacturing technically contributed most to the acceleration in growth of market sector labour use. Table 3.3 shows, however, that this was mostly the result of a recovery in labour use, after labour shedding in the second cycle.

Agriculture, Mining and Transport also made sizeable contributions (around 0.2 percentage points) to the acceleration in labour use.

Figure 3.4 Industry contributions to increased growth in market sector hours worked over successive productivity cycles



Data source: Author's estimates based on ABS data (see appendix A).

3.2 A different reallocation of output

Output growth was a strong 4.0 per cent a year over the 2003-04 to 2007-08 cycle. This was up from 3.4 per cent a year over the previous cycle. But it was not as strong as the 4.9 per cent a year recorded over 1993-94 to 1998-99 (table 3.4).

On a passing technical note, the estimation of industry contributions to output growth are not as precise as they are for input growth. This is manifest in the discrepancies between the market sector output growth rates displayed on the left hand side of table 3.4 (from market sector data) and on the right hand side (derived from the contribution methodology). (See appendix A.)

The pattern of industry contributions to output growth was very different from the pattern of industry contributions to input growth. In particular, Financial & insurance services had very strong output growth, but the industry did not feature at all in the more rapid accumulation of inputs in the second phase of the productivity growth slump. Financial & insurance services output growth, measured at 8.2 per cent a year in the last cycle, contributed 1.2 percentage points of the 4.0 per cent annual average growth in market sector output in that cycle. It added an extra 0.4 percentage points to market sector output growth in the last cycle, compared with the previous cycle (figure 3.5).

	U		•	•	5 5	
Industry	Growth rate	es (per cent p	er year)	Contributio	ns (percentag	e points)
	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08
Agriculture	4.1	2.3	-0.8	0.20	0.04	-0.04
Mining	3.9	2.1	4.3	0.29	0.15	0.42
Manufacturing	2.1	2.0	1.1	0.47	0.39	0.17
EGWWS	1.8	1.3	0.9	0.09	0.06	0.04
Construction	5.6	4.8	6.1	0.56	0.43	0.70
Wholesale	6.4	3.2	3.0	0.54	0.27	0.24
Retail trade	4.5	4.5	4.2	0.39	0.38	0.35
Accom and food	5.3	3.1	2.2	0.22	0.13	0.09
Transport, post, warehsg	4.5	3.9	4.9	0.39	0.33	0.43
Info, media, Telecomms	7.7	3.9	4.6	0.49	0.25	0.27
Financial & insurance	5.6	5.7	8.2	0.69	0.80	1.23
Arts & recreational	3.6	3.6	4.0	0.06	0.06	0.07
Market sector ^b	4.9	3.4	4.0	4.4	3.3	4.0

Table 3.4Industry growth in output and contributions to market
sectora growth in output over productivity cycles

 a 12-industry market sector. b The market-sector growth rates on the left hand side of the table are as published by the ABS. The rates on the right hand side are the sums of contributions as derived from the methodology set out in appendix A..

Source: Author's estimates based on ABS data (see appendix A).

Mining, Construction and Transport all lifted their contributions to output growth (by 0.3 percentage point, 0.3 percentage point and 0.1 percentage point respectively) in the third cycle. The other faster input accumulators — Manufacturing, Agriculture, Wholesale trade, Retail trade and EGWWS — did not increase output growth in the last cycle (figure 3.5).
Figure 3.5 Industry contributions to increased growth in marketsector output over successive productivity cycles percentage points



Source: Author's estimates based on ABS data (see appendix A).

3.3 MFP implications

MFP growth lifted to a record high of 2.5 per cent a year over the first cycle, dropped back to 1.2 per cent a year in the second cycle, and then fell to zero over the third cycle (table 3.5).

There was rapid decline in MFP (over 4 per cent a year) in EGWWS and Mining in the last cycle. However, because of size differences, their contributions to aggregate MFP growth differed. (See box 3.1 about industry MFP contributions.) Mining (-0.4 percentage points) and Manufacturing (-0.3 percentage points) were the major detractors from aggregate MFP growth in the last cycle. EGWWS (-0.2 percentage points) came in third, followed by Retail trade, Agriculture and Arts & recreational services. All these industries were more rapid input accumulators in the third cycle.

	•		•	-	2		
Industry	Growth rat	tes (per cent p	er year)	Contributions (percentage points)			
	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	
Agriculture	3.9	3.5	-1.5	0.19	0.19	-0.06	
Mining	0.6	0.0	-4.1	0.03	-0.01	-0.43	
Manufacturing	0.6	1.3	-1.4	0.13	0.26	-0.26	
EGWWS	1.9	-2.3	-4.9	0.06	-0.08	-0.18	
Construction	2.5	0.9	0.6	0.27	0.03	0.07	
Wholesale	5.2	1.3	0.0	0.44	0.11	0.01	
Retail trade	2.1	1.4	0.3	0.14	0.06	-0.07	
Accom and food	1.7	0.8	0.4	0.01	0.00	0.00	
Transport, post, warehsg	2.0	1.7	0.7	0.19	0.15	0.06	
Info, media, Telecomms	2.8	-1.0	0.1	0.19	-0.05	0.00	
Financial & insurance	2.8	2.3	4.3	0.38	0.37	0.81	
Arts & recreational	-1.9	1.0	-1.9	-0.04	0.01	-0.05	
Market sector ^b	2.5	1.2	0.0	2.0	1.0	-0.1	

Table 3.5Industry growth in MFP and contributions to market
sectora growth in MFP over productivity cycles

 a 12-industry market sector. b The market-sector growth rates on the left hand side of the table are as published by the ABS. The rates on the right hand side are the sums of contributions as derived from the methodology set out in appendix A.

Source: Author's estimates based on ABS data (see appendix A).

Again, though, the chief interest is in the change in MFP growth and the industry contributors to the productivity slump (box 3.1).

Figure 3.6 shows that:

- the three biggest contributors to the fall in MFP growth from its 2.5 per cent a year peak in the first cycle to 1.2 per cent a year in the second cycle were Wholesale (-0.3 percentage points), Construction (-0.2 percentage points) and Telecomms (Information media & telecommunications) (-0.2 percentage points); and
- the three biggest contributions to the further slump to zero MFP growth in the second phase came from Manufacturing (-0.5 percentage points), Mining (-0.4 percentage points) and Agriculture (-0.2 percentage points).

Box 3.1 Calculating industry contributions to aggregate MFP growth

Industry contributions to aggregate MFP growth are calculated in this paper from their separate contributions to aggregate output and input growth, rather than from estimates of industry MFP.

There is a technical reason. The ABS calculates market-sector MFP from separate indexes of market-sector output and market-sector inputs. Different methods of aggregation are used in forming the output, capital and labour indexes. Although the ABS also estimates industry MFP, it is not possible to aggregate these indexes with a single aggregation method that exactly reproduces the market sector MFP estimates. Consequently, the ABS method of estimating aggregate MFP from separate output and input indexes is followed here, and an industry's contribution to aggregate MFP growth is the net result of its separate contributions to aggregate output growth, capital growth and labour growth. (Note how in table 3.5 Retail's MFP growth is estimated as positive in the third cycle, and yet its contribution to aggregate MFP growth is estimated as negative.)

Another problem that plagues the estimation of industry contributions to aggregate productivity growth over periods such as productivity cycles concerns the choice of industry weights to use. Should it be the base-period weights, end-period or some average? Whatever the choice, there are inevitable approximation errors between the sum of the industry contributions and the growth in independently estimated aggregates. Approximation errors over intervals such as productivity cycles have been exacerbated in recent times by the introduction of chain volume measures into the data. These effectively update industry weights in aggregate series every year.

The method developed in this paper solves these problems. It uses information on industry shares from each year and accumulates the *annual* industry contributions over the period of interest.

The end result is that the industry decompositions of aggregate MFP growth are exact (in theory), or very close to it (in practice). Decompositions are possible not only in terms of industry MFP contributions, but also in terms of industry output, capital and labour contributions.

The methodology is set out in appendix A. Results are presented throughout this section.



Industry contributions to the decelerations in market Figure 3.6 sector MFP growth over successive productivity cycles

Source: Author's estimates based on ABS data (see appendix A).

These changes in industry MFP contributions can be decomposed into changes in output and input contributions. The change in an industry's MFP contribution is the difference between the change in the industry's output contribution and the change in its input contribution. These decompositions are shown in figure 3.7, in relation to the first phase of the MFP growth decline and in figure 3.8, in relation to the second phase. The two charts are drawn on the same scale for easy comparison.

Signs of unrequited input growth at the industry level

In the comparison of the first two cycles (figure 3.7) the decline in MFP contributions from Wholesale trade and Information. media and telecommunications, were predominantly due to lower output contributions. As previously noted. Construction and EGWWS did show early signs of unrequited input growth, even though it was not apparent at the aggregate level. (Note the changes in contributions are enumerated in the next section.)

Figure 3.7 Change in industry input, output and MFP contributions between cycle 1993-94 to 1998-99 and cycle 1998-99 to 2003-04



Source: Author's estimates based on ABS data (see Appendix A).

Figure 3.8 Change in industry input, output and MFP contributions between cycle 1998-99 to 2003-04 and cycle 2003-04 to 2007-08



percentage points

Source: Author's estimates based on ABS data (see Appendix A).

The signs of unrequited input growth were stronger in the second phase (figure 3.8). A stronger input contribution was the dominant factor in all industries that experienced a lower MFP contribution. The large fall in Manufacturing's and Agriculture's MFP contributions was also in large part due to a fall in output contribution. In Mining's case, there was a positive contribution from stronger output growth but it fell well short of the increase in input contribution.

Construction, however, did not make a contribution to the productivity slump. Its output contribution increased by more than the change in its input contribution.

Financial & insurance services stands out as the only industry that made a positive contribution (0.4 percentage point) to a change in aggregate MFP growth over the last two cycles (figure 3.6). Figure 3.8 shows that this was almost entirely due to a higher output contribution.

3.4 Complete industry contributions

The methodology developed in appendix A can be used to provide a complete disaggregation of market-sector MFP growth into industry contributions not only from MFP, but also from labour, capital and output growth.

Contributions tables for MFP growth within cycles

In terms of presentation of results, the first step is to gather the industry contributions to total input growth (table 3.1), output growth (table 3.4) and MFP growth (table 3.5). This step is provided in table 3.6. Since MFP growth equals output growth less input growth, estimates in the three columns under the MFP heading are equal to the estimates in the same columns under the Output heading *minus* the estimates in the same columns under the Total inputs heading. And so, for example, the -0.43 percentage point contribution from Mining to MFP growth in the last cycle (in the right-most column of the table) is equal to an output contribution of 0.42 percentage point (third column under Output) minus a total input contribution of 0.85 percentage point (third column under Total inputs).

The second step is to provide industry contributions to labour and capital growth as a disaggregation of their contributions to total input growth. The contributions in tables 3.2 and 3.3 do not suffice for this purpose, as industry contributions to labour and capital growth need to be weighted by shares of labour and capital in each industry's costs (see appendix A). This step is provided in table 3.7. In this case, the estimates in the three columns under Labour *plus* the estimates in the same columns under Capital equal the estimates in the same columns under Total inputs.

	Input contribution (1)		Output contribution (2)			$MFP \ contribution = (2) - (1)$			
	93-94 to 98-99	98-99 to 03-04	03-04 to 07-08	93-94 to 98-99	98-99 to 03-04	03-04 to 07-08	93-94 to 98-99	98-99 to 03-04	03-04 to 07-08
Agriculture	0.01	-0.15	0.02	0.20	0.04	-0.04	0.19	0.19	-0.06
Mining	0.26	0.16	0.85	0.29	0.15	0.42	0.03	-0.01	-0.43
Manufacturing	0.34	0.13	0.43	0.47	0.39	0.17	0.13	0.26	-0.26
EGWWS	0.03	0.14	0.21	0.09	0.06	0.04	0.06	-0.08	-0.18
Construction	0.30	0.40	0.63	0.56	0.43	0.70	0.27	0.03	0.07
Wholesale	0.11	0.16	0.24	0.54	0.27	0.24	0.44	0.11	0.01
Retail	0.24	0.32	0.42	0.39	0.38	0.35	0.14	0.06	-0.07
Accom & food	0.21	0.14	0.09	0.22	0.13	0.09	0.01	0.00	0.00
Transport	0.20	0.18	0.37	0.39	0.33	0.43	0.19	0.15	0.06
Telecoms	0.30	0.30	0.27	0.49	0.25	0.27	0.19	-0.05	0.00
Financial	0.31	0.43	0.42	0.69	0.80	1.23	0.38	0.37	0.81
Arts & rec	0.09	0.05	0.12	0.06	0.06	0.07	-0.04	0.01	-0.05
Market sector	2.4	2.3	4.1	4.4	3.3	4.0	2.0	1.0	-0.1
Published	2.4	2.3	4.1	4.9	3.4	4.0	2.5	1.2	0.0

Table 3.6Contributions to market sector MFP growth over cycles
percentage points

Source: Author's calculations (see appendix A).

Table 3.7	Contributions to market sector input growth over cycles
	percentage points

	Labour contribution (1)		Capital contribution (2)			Total input contribution = $(1) + (2)$			
	93-94 to 98-99	98-99 to 03-04	03-04 to 07-08	93-94 to 98-99	98-99 to 03-04	03-04 to 07-08	93-94 to 98-99	98-99 to 03-04	03-04 to 07-08
Agriculture	0.00	-0.15	-0.03	0.01	0.00	0.04	0.01	-0.15	0.02
Mining	-0.02	0.02	0.14	0.28	0.14	0.71	0.26	0.16	0.85
Manufacturing	0.01	-0.14	0.02	0.33	0.27	0.41	0.34	0.13	0.43
EGWWS	-0.04	0.03	0.06	0.07	0.11	0.15	0.03	0.14	0.21
Construction	0.21	0.31	0.46	0.09	0.09	0.18	0.30	0.40	0.63
Wholesale	-0.03	0.02	0.02	0.13	0.14	0.22	0.11	0.16	0.24
Retail	0.13	0.21	0.27	0.11	0.11	0.15	0.24	0.32	0.42
Accom & food	0.17	0.10	0.04	0.04	0.04	0.05	0.21	0.14	0.09
Transport	0.13	0.06	0.15	0.07	0.13	0.21	0.20	0.18	0.37
Telecoms	0.02	0.05	0.03	0.29	0.25	0.23	0.30	0.30	0.27
Financial	0.04	0.05	0.12	0.28	0.38	0.30	0.31	0.43	0.42
Arts & rec	0.05	0.01	0.08	0.04	0.03	0.03	0.09	0.05	0.12
Market sector	0.7	0.6	1.4	1.7	1.7	2.7	2.4	2.3	4.1
Published	0.7	0.6	1.4	1.7	1.7	2.7	2.4	2.3	4.1

Source: Author's calculations (see appendix A).

Following the Mining example, the industry's contribution of 0.85 percentage point to market sector growth in total inputs of 4.1 per cent a year in the last cycle is comprised of a labour contribution of 0.14 percentage point plus a capital contribution of 0.71 percentage point.

Contributions tables for the slowdowns in MFP growth between cycles

The above contributions tables can be reconfigured to show industry contributions to the slump in productivity growth over the two phases. Contributions to the slowdown between the first and second cycles are shown in table 3.8 (which corresponds with estimates presented in figure 3.7). Contributions to the slowdown between the second and third cycles are in table 3.9 (which corresponds with estimates in figure 3.8).

The contributions of Wholesale (0.3 percentage points), Telecomms (0.2 percentage point) and Construction (0.2 percentage points) to the first stage of the slowdown were previously noted. The Wholesale and Telecomms falls were due predominantly to output declines. The Construction fall was shared between input growth and output decline. The additional information in table 3.8 is that the increase in input contribution in Construction was entirely due to greater use of labour.

Manufacturing (0.5 percentage points) and Mining (0.4 percentage points) contributed most to the second phase slump.

The biggest number in table 3.9 — or the largest single contribution to the decline in productivity growth — is the 0.58 additional capital contribution in Mining. That is, more rapid accumulation of capital in Mining, on its own, accounted for half of the 1.1 percentage points contribution decline in aggregate MFP growth. There was an additional 0.1 percentage point from increased use of labour. But, of course, there was also increased output (its contribution increased by 0.3 percentage points) and so the overall effect on aggregate MFP growth was reduced to -0.4 percentage points.

The largest source of output decline was in Manufacturing. This took 0.2 percentage points off MFP growth. At the same time, greater use of labour in Manufacturing took off another 0.2 percentage points and greater use of capital took off another 0.1 percentage points.

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Table 3.8Changes in industry contributions to aggregate MFP
growth between cycles 1 and 2

	Labour	Capital	Output	MFP
Agriculture	-0.15	-0.01	-0.17	0.00
Mining	0.04	-0.14	-0.14	-0.04
Manufacturing	-0.15	-0.06	-0.08	0.13
EGWWS	0.07	0.04	-0.03	-0.14
Construction	0.11	0.00	-0.13	-0.24
Wholesale	0.05	0.01	-0.28	-0.33
Retail	0.08	0.00	0.00	-0.08
Accom & food	-0.07	0.00	-0.08	-0.01
Transport	-0.08	0.06	-0.06	-0.04
Telecomms	0.03	-0.03	-0.24	-0.24
Financial	0.01	0.11	0.11	-0.01
Arts & rec	-0.04	-0.01	0.01	0.05
Market sector	-0.1	0.0	-1.1	-1.0
Published	-0.1	0.0	-1.4	-1.3

percentage points

Source: Author's estimates based on ABS data (see appendix A).

Table 3.9Changes in industry contributions to aggregate MFP
growth between cycles 2 and 3

	Labour	Capital	Output	MFP		
Agriculture	0.13	0.04	-0.08	-0.25		
Mining	0.11	0.58	0.27	-0.42		
Manufacturing	0.16	0.14	-0.22	-0.52		
EGWWS	0.03	0.05	-0.02	-0.09		
Construction	0.14	0.09	0.27	0.04		
Wholesale	0.00	0.08	-0.02	-0.10		
Retail	0.06	0.04	-0.04	-0.13		
Accom & food	-0.05	0.01	-0.04	0.00		
Transport	0.10	0.08	0.10	-0.08		
Telecomms	-0.02	-0.02	0.02	0.05		
Financial	0.08	-0.09	0.43	0.44		
Arts & rec	0.07	0.00	0.00	-0.06		
Market sector	0.8	1.0	0.7	-1.1		
Published	0.8	1.0	0.6	-1.2		

percentage points

Source: Author's estimates based on ABS data (see appendix A).

Agriculture had the third largest fall in MFP growth contribution between the last two cycles. It picked up more labour, which took 0.1 percentage points off MFP growth and its output declined, which took another 0.1 percentage points off. There was also a small increase in capital contribution.

Transport was another of the major faster input accumulators. Increased use of labour and capital in the industry each took roughly 0.1 percentage point off market sector MFP growth, but those negatives were partially offset by an increase in output contribution of 0.1 percentage points.

Although Construction was another of the major faster input accumulators, its output growth meant that it did not detract from overall MFP growth. Table 3.9 shows that there were sizeable increases in input contributions, especially on the labour side, but also on the capital side.

Collectively, the major faster input accumulators — Mining, Manufacturing, Construction, Transport and Agriculture — took 1.2 percentage points off market sector productivity growth. That is, they accounted for the entire *net* decline in MFP growth between the last two cycles (see the next sub-section for the distinction between gross and net decline).

The remaining faster input accumulating industries — Retail, Wholesale, EGWWS and Arts & recreational services — collectively took off a more modest four tenths of a percentage point between the second and last cycles.

The negative contribution of this latter group was offset by the positive contribution of Financial & insurance services. (Information media & telecommunications also made a minor positive contribution.)

Compatibility with Productivity Commission assessments

The Productivity Commission previously identified that three industries — Agriculture, Mining and EGWWS — accounted for around 70 per cent of the decline in market-sector MFP growth (PC 2009, 2010). These three industries were selected on the basis that their measured MFP performance was clearly subject to extraneous ('special') factors — drought, commodity prices and changes in preferences, technologies and standards.

A very similar attribution can be drawn from the figures presented here. On the figures presented in table 3.9, these three industries accounted for just under 70 per cent of the decline in MFP growth of 1.1 percentage points.

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This does not appear to leave much room for the contribution of Manufacturing and other industries to the fall in aggregate MFP growth. However, the fall of 1.1 percentage points in aggregate MFP growth is the net result of a 1.7 percentage point fall from the group of industries that made negative contributions and a 0.5 percentage point increase from the group of industries (mostly Financial) that made positive contributions.

An alternative way to present the attributions would be to say that the three industries highlighted by the Commission account for just under half (46 per cent) of the 1.7 percentage point negative contribution from the group of industries that had lower MFP in the last cycle.³ On that same basis, the three industries that contributed *most* to the decline in market-sector MFP were Manufacturing (30 per cent), Mining (25 per cent) and Agriculture (15 per cent). Collectively, they accounted for 70 per cent of the gross decline in MFP growth.

A check on underlying industry contributions

Barnes (2011) illustrated that the length and timing of specific-industry cycles can and do differ from those of aggregate market-sector cycles. That is, an industry's cycle of peak to peak productivity can differ from that of the market sector. It is therefore possible that some of the industry contributions estimated above are under- or over-stated relative to underlying industry productivity trends. For example, if an industry's MFP went from below trend in 2003-04 to above trend in 2007-08 its contribution to aggregate MFP growth, as estimated above, would partly reflect a cyclical element, rather than purely an underlying trend.

It would appear from Barnes' work that there may be a small industry-cycle component in Mining's negative contribution to the productivity downturn, which overstates its contribution.⁴ Since Manufacturing cycles correspond to market-sector cycles, there would be no industry-specific cycle component in Manufacturing's contribution. According to Barnes' comparisons, there is also a slight understatement in the fall in Construction's contribution.⁵

³ Mining contributed 25 per cent, Agriculture 15 per cent and EGWWS 6 per cent.

⁴ On Barnes' numbers, this was a difference between annual average MFP growth of -3.9 per cent over the industry cycle from 2000-01 to 2006-07 compared with -4.2 per cent over the market-sector cycle from 2003-04 to 2007-08.

⁵ This was a difference between annual MFP growth of 0.5 per cent over the industry cycle from 2002-03 to 2007-08, compared with 0.8 per cent over the market-sector cycle, 2003-04 to 2007-08.

3.5 Summary

The faster input acceleration became apparent at the aggregate level in the mostrecent cycle. While faster input accumulation was widespread across industries, it was highly skewed. The faster input accumulation at the aggregate level was predominantly due to the more rapid accumulation of capital in Mining, which took off after 2004-05. Comparing cycles 2 and 3, mining accounted for 40 per cent of the additional input growth in the third cycle and 60 per cent of the additional growth in capital.

There was a strong correlation between faster input accumulation and contribution to the second-phase slump in productivity growth.

Mining contributed 0.4 percentage points to the MFP growth slump. It had an increase in output contribution, but that did not make up for the productivity-sapping effect of its higher input use. Most of the growth was in input use was in additional capital. Mining's capital stock grew at 8 per cent a year over the last cycle, and that provided 60 per cent of the additional growth in market sector capital. The capital contribution was -0.6 percentage points. There was another -0.1 percentage point contribution from additional use of labour. Additional output growth in the last cycle added 0.3 percentage points, which left Mining with a net contribution of -0.4 percentage points to a change in aggregate productivity growth.

Manufacturing was the next biggest contributor to the acceleration in input use. It accounted for 17 per cent. A little more of its input contribution came through additional use of labour (closer to -0.2 percentage points) than it did from additional capital (closer to -0.1 percentage points). However, Manufacturing suffered a fall in output contribution. Output contributed -0.2 percentage points to a change in aggregate productivity growth. Manufacturing thus took 0.5 percentage points off aggregate MFP growth.

Construction was the next biggest input accumulator (13 per cent), but because of its stronger output growth, it made a small positive contribution to the change in MFP growth over the last two cycles. Its more rapid accumulation of inputs, and especially labour, began in the second cycle.

Transport, post & warehousing accounted for 10 per cent of the more rapid growth in inputs. It detracted from productivity growth with an additional 0.1 percentage point labour contribution and 0.1 percentage point capital contribution. Additional output growth offset these to the extent of 0.1 percentage points, and so the industry's net contribution was to take 0.1 percentage points off aggregate MFP growth.

Agriculture, forestry & fishing contributed 9 per cent of the additional growth in inputs. This was chiefly increased labour — and a reversal of the labour shedding that had taken place in the previous cycle. A decline in output in the last cycle, however, reduced the industry's contribution to aggregate MFP growth by 0.1 percentage point. The industry's total contribution was approaching 0.3 percentage point lower.

The other faster input accumulators — Retail trade, Wholesale trade, EGWWS, and Arts & recreational services — made no or negative contributions to change in output growth. They each took 0.1 percentage point off aggregate MFP growth. EGWWS was another industry that began its faster input accumulation in the second cycle.

The three biggest contributors to the second phase of productivity slump were Manufacturing (0.5 percentage points), Mining (0.4 percentage points), and Agriculture (0.3 percentage point). These were all faster input accumulators.

While there is a strong common thread — faster input accumulation — among industries, there is enough variation in extent, timing and combination with different output effects to suggest that there may be important differences in their explanatory stories.

4 Deeper reasons: crisis or adjustment?

This chapter looks for deeper or underlying reasons for the productivity growth slump. It looks more for industry-specific than for general reasons because, as the last chapter showed, the faster input accumulation and the contributions to the slowdown in productivity growth were skewed across industries. This suggests industry stories are important.

The review of industries relies heavily on other studies. New industry investigations were beyond the scope of this paper.

The chapter also returns to the 'usual suspects', identified in chapter 1, that are often called on to explain a suspiciously-low or negative rate of MFP growth.

The chapter ends with a conclusion, as best as can currently be determined, about the extent to which the slump in Australia's productivity growth over the 2003-04 to 2007-08 cycle represents a 'crisis'. General implications and areas for further research are also included.

4.1 Industry profitability

It was pointed out in chapter 2 that profitability had increased in the 2000s. Higher output prices would justify input accumulation at a faster rate than output growth. Some information on profitability in specific industries is now presented as a backdrop to the industry reviews that follow.

The increase in profitability has been concentrated in a few industries. Figure 4.1 shows the internal rates of return on capital (for selected industries) that are derived from the ABS national accounts.¹ Strong growth in returns in Construction and Financial & insurance services, dating from the late 1990s, is clearly evident. Mining returns increased substantially from 2003-04.

¹ The ABS has estimates of capital income from data on gross operating surplus (GOS) and a proportion of gross mixed income (GMI). The internal rates of return come from back-solving the rental price formula to equate a calculated capital income (productive capital stock multiplied by rental prices) with the GOS plus GMI data. The estimates presented here do include the imposition of a 'floor' when implied returns turn negative in any year. However, this is unlikely to be of great consequence for the industries and time period considered.

Returns in other industries, such as those shown for Manufacturing and EGWWS, did not have a clear overall trend. Importantly, though, they did not show a decline, which might be expected if they invested in more capital but could only rely on output growth as a source of income.



Figure 4.1 Internal rates of return in selected industries

Data source: Unpublished ABS data.

Estimates of the ratio of net company profits to net capital stocks for individual industries (industry groups were reported in chapter 2) tend to confirm these trends, although Manufacturing increased more in the early 2000s and Mining jumped higher after 2004-05. The profit ratio in Wholesale jumped in the early 2000s and remained high throughout the 2000s and the profit ratio for Retail climbed throughout the 2000s.

Profitability is clearly higher in the 2000s and much wider than the direct effects of higher commodity prices in mining.

4.2 Industry reviews

These reviews concentrate on the industries that were the main faster input accumulators.

Mining

As the previous chapter showed, the Mining industry was the main source of the more rapid input accumulation. While output growth did lift, it failed to match the effect that input growth had on aggregate MFP growth.

The Mining industry has, of course, had the benefit of steeply rising output prices, which have boosted profits well beyond the extent that additional output growth alone would provide. Figure 4.2 provides an indication of the relative price shift in favour of mining. It shows the mining implicit price deflator, relative to the GDP implicit price deflator.² It reveals that prices available to miners increased two-fold between 2003-04 and 2008-09, relative to those available to producers in general. Because these are implicit prices for mining value added, they represent increases in prices received net of prices paid (for material inputs, energy and so on). And, because the prices are also calculated relative to the GDP deflator, the effect of general inflation in producer prices has been removed. This price index shows how much mining output prices have moved ahead of input prices (relative to the economy in general).³

These price rises were a source of additional income to miners (beyond general inflationary effects) that were not reflected in the measurement of mining output. The ABS measures mining output in terms of the volumes produced, which are related to physical units such as tonnes of ore extracted and ready for sale. Any increase in commodity price is stripped out of the output measure.

Topp et al. (2008) explored specific reasons for the decline in measured Mining productivity in the 2000s. They offered two main explanations:

- a decline in the 'quality' of resource deposits, which means more inputs are required to extract a given volume of output (and efforts to extract even more volumes have been propelled by the higher prices now paid per unit of output); and
- lags between the flows of capital investment in exploration and mine development, on the one hand, and the full production flows from new mines;

² The index is an implicit price of a unit of mining value added divided by the implicit price of a unit of economy-wide value added. Dividing by the GDP deflator removes the effects of general price movements from the index.

³ The price index does not include changes in labour and capital costs of extraction beyond the general price level. This would not be too much of a problem if labour and capital costs in mining kept in line with factor costs generally (they would roughly net out in adjustments to mining prices and economy-wide prices). Resource rents would be lower than indicated by the price index to the extent that higher wages and higher returns were necessary to attract labour and capital into mining to extract the more valuable resources.

- investment is counted in the productivity accounts as fully-productive additions to the capital stock as soon as it occurs, whereas associated production may only come on stream some years down the track.



Figure 4.2 Relative prices for selected industries

Source: Author's calculations based on data from ABS (2011a) and unpublished data.

Both of these developments have been underwritten by the rapid rise in commodity prices. Expectations about higher output prices make it worthwhile to commit additional inputs, even though less growth in the volume of output may eventuate.⁴ The price 'shock' also precipitated a massive increase in investment in the industry that has yet to yield its full output response.

Topp et al put some orders of magnitude on these effects. They decomposed a fall in Mining MFP of 24 per cent between 2000-01 and 2006-07 into a depletion effect of -24 per cent and a capital lag effect of -8 per cent, offset by other factors of 8 per cent. The depletion effect was found to be strong in oil and gas extraction, whereas the capital lag effect was prominent in coal mining and iron ore mining.

⁴ The implicit proposition here is that new mines are operating on deposits that are more marginal in some sense.



Manufacturing

Further work is needed to identify the causes of the productivity decline in Manufacturing. There is no doubt, however, that the sector has been facing adjustment pressures, not least being the referred pressures from the mining boom including a higher exchange rate,

Examination of year-to-year contributions to MFP growth does not indicate clear trends that might point to what went on. Figure 4.3 suggests that there was some additional capital contribution over the latest cycle, but partly because the capital contribution was weaker than usual around the turn of the millennium. The labour contribution may also have been greater, but its continued volatility tends to stand out more than does a clear trend. The decline in output contribution between 2003-04 and 2005-06 appears to be a clearer reason for the fall in Manufacturing's overall contribution to market sector MFP growth. Curiously, this was at the same time that there was stronger capital accumulation. It is quite possible that there were different trends within the industry, with perhaps mining-related investment in some segments of manufacturing and output declines in other segments.

Construction

Construction was a major input accumulator, but it had sufficient output growth that it did not add to the MFP growth slowdown over the latest two cycles.

In this industry's case, the question might be more about why productivity growth did not rise by more, given its strong output growth (just over 6 per cent a year in the third cycle). On the face of it, the strong build-up of labour over the two most recent cycles (table 3.7 and 3.8) seems surprising, especially when the mix of activity within the industry has been shifting toward larger-scale engineering construction. Construction is now the biggest user of labour (on an hours worked basis) at the industry division level.



Figure 4.3 Manufacturing contributions to annual growth in market sector MFP percentage points

Source: Author's estimates based on ABS data (see appendix A)

EGWWS

The contributions analysis in the previous chapter attributed 0.1 of a percentage point of the MFP growth fall to EGWWS. Most (about three-quarters) of this was due to additional input use.

Topp and Kulys (2012) investigate the decline in productivity in EGWWS and identify a number of explanations.

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- Cyclical investment: the long capital cycles in utilities and associated variations in utilisation rates.
 - Substantial lumpy investments in new capacity are made from time to time. All available productive capacity is counted for capital input purposes, but utilisation rates may be relatively low after the installation of new capacity, leading to a fall in measured productivity. Productivity growth then rises with greater utilisation as the population and demand grows.
 - Whereas growth in demand could be met through increased utilisation from the late 1980s and through the 1990s, new investment in capacity was required from the late 1990s.
- Additional costs in meeting demands: concerns about security of supply have led to increases in capital, but effects on output are not captured in measurement.
 - Prolonged drought led State governments to install desalination plants in order to shore up security of water supply. These had high capital costs, but any effect on output beyond actual delivery of water (such as any 'insurance' benefits from security of supply) is not taken into account in the productivity measures.
 - The peak requirements for electricity generation have increased with greater penetration of air conditioners. Greater capacity has been installed to meet peak demand (providing security of supply) but, since more capacity lies idle in non-peak times, capital requirements per unit of output have increased.
- Technological change: mandated shifts in technology increase input requirements without the same increase in output.
 - Shifts from coal-fired electricity generation to gas-fired and renewables, with their higher input requirements, have been driven by government measures.
- Unmeasured quality change increases in input requirements to meet higher quality standards that are not reflected in output measures.
 - There has been a switch from overhead toward underground cabling of electricity distribution.
 - Standards and regulations have been tightened in relation to the treatment and disposal of sewage and waste water, leading to increases in use of capital and labour. Improved quality, however, is not reflected in output measures.

Output in this industry is measured in terms of physical units of energy generated and distributed, of water delivered and of waste treated. Improvements in quality and any gains from security of supply and lower-emissions generation are not taken into account. Because these changes require additional inputs, measured productivity is lower than it would otherwise be. Relative price increases, and some additional government funds, provide the funding base for the additional input requirements.

Transport

An explanation for the unrequited input accumulation in Transport is not to hand.

The industry accounted for a 0.1 percentage point fall in market-sector MFP growth. It had a large increase in input contribution (0.2 percentage point), partially offset by a higher output contribution (0.1 percentage point).

Again, there may be a mining-related component. It may be that the increased input use is associated with investment in transport infrastructure, which is included in the capital stock of the Transport industry in the ABS national accounts. An analysis is yet to be undertaken.

Agriculture

Agriculture contributed one quarter of a percentage point of the productivity slump between the latest two cycles.

The Productivity Commission has highlighted the role of drought in reducing Agriculture MFP over the last productivity cycle. Drought had an especially severe effect on output in 2006-07, when value added fell by 15.3 per cent (PC 2010). While output and MFP did subsequently recover, it was not until the 2008-09 year. The drought acted as a drag on productivity over the market sector cycle from 2003-04 to 2007-08.

There was also an increase in input use. Some of this may also be attributable to drought, if it came about by reason of hand watering and feeding and making extra investments to drought-proof properties.

4.3 The 'usual suspects'

As mentioned in chapter 1, productivity analysts get suspicious about negative (or very low) measured rates of productivity growth. Rather than accept them at face value as implying loss of knowledge or efficiency, they call on a number of 'usual suspects' to explain them.

The key point is that, to the extent that these other explanations are at work, a decline in the level (or rate of growth) of measured productivity does not represent a prosperity-sapping loss of efficiency.

This section reviews developments in the 2000s from the 'usual suspects' perspective. While, to a large extent, it represents a reorganisation of material just presented in the industry reviews, there is some additional discussion on some of the suspects.

The examination of the usual suspects is neither complete nor precise. Some developments are not included because of lack of information. Some developments can and do fall into more than one category, and categorisation can always be contentious.

Volatility and cycle effects

It is well known that productivity can decline during a downturn in the business cycle. Businesses run capital at a lower rate of utilisation and often hoard labour when the rate of output declines in the short term. This typically shows up as a decline in productivity level or growth over a year or two. The decline is usually followed by a 'bounce back' to normal levels of, and rates of growth in, productivity when output recovers.

General effects of the business cycle on the productivity growth slump can essentially be ruled out. As chapter 2 illustrated, the slump is quite evident when business cycle effects are removed by the use of productivity cycles to assess underlying rates of productivity growth.

Nevertheless, the industry reviews in the last section highlighted some other industry-specific developments that have the pattern of a period of productivity decline, followed by a bounce-back:

- a 'lumpy' investment story in EGWWS where part of the capital build-up was a concentration of replacement and refurbishment of a number of plants coming to the end of their effective lives:
 - the period of growth in capacity, without the same growth in output, has reduced productivity in the measurement period but will be counterbalanced in the future by a period in which output growth can be met by raising capacity utilisation, rather than adding additional capital capacity; and
- though not part of a regular pattern, drought introduced volatility into agricultural productivity:

- the drought reduced agricultural output in the short-term, and probably increased input use as it persisted. These effects have reversed now the drought has broken. However, since the drought broke outside of the measurement period, it contributed to the productivity growth slump over the measurement period.

These declines in productivity are not of in-principle concern in terms of loss of efficiency or prosperity. Provided the investment decisions in EGWWS were in keeping with optimal maintenance and replacement patterns, they merely represent the normal long investment cycles in this industry. In the case of agriculture, there may have been some opportunities for resource savings, but only with the benefit of hindsight. The prior commitment of resources could well have been justified, whereas the weaker-than-expected outcome was due to the vagaries of weather.

Compositional shifts

To the extent that productivity levels differ across industries (and firms), shifts in the relative size of industries (and firms) toward those with relatively low productivity would reduce aggregate productivity.

Connolly and Lewis (2010) showed that there was more structural change across industries and States in the 2000s than in the 1990s. Their indexes of structural change are reproduced here in figure 4.4. The Mining industry played a large role in the increased structural change across both industries and States.

The effects of shifts in inputs between industries on aggregate MFP growth over the last two cycles are estimated to have reduced annual market sector MFP growth by 0.1 of a percentage point (appendix B). All of this came from reallocation to the Mining industry, which was undergoing an MFP decline.

Construction also had a more substantial negative effect on aggregate productivity through a compositional effect in the second cycle.

Figure 4.4 Indexes of structural change across industries and States^a



^a The index is half the sum of the absolute value of changes in five-year average nominal industry or State shares, based on the final year shown.. *Data source*: Connolly and Lewis (2010).

On a technical issue, the methodology developed in this paper, which estimates the effects of compositional shifts on MFP, is an alternative to the usual approach of analysing the compositional effects on labour productivity. The effects on MFP are found to be minor in both absolute terms and relative to effects on labour productivity.⁵ (The above 0.1 percentage point effect in the last cycle is unusually large in the context of effects estimated over the two and a half decades.) This suggests that the generally larger compositional effects on labour productivity have a lot to do with industry differences in capital intensity, rather than efficiency (MFP).⁶

Adjustment processes

An economic development could induce businesses to invest in new capital (physical, human and intangible) over a period in pursuit of a future return. This would be observed as a step up in input use (and lower productivity) in the short run. A future increase in productivity level or growth would usually be expected.

⁵ Industry composition effects on labour productivity were analysed in the early stages of the research project. The study by Ewing et al (2007) provides a published example.

⁶ Labour productivity is a function of the capital-to-labour ratio and MFP.

For example, the introduction of a new technology might bring a period of investment in new physical capital and retraining, during which productivity would be lower. Subsequently, however, productivity will likely settle at a higher level than was in place before the investment. It may also settle at a higher rate of productivity growth if dynamic or 'endogenous' growth aspects are tapped in the adjustment process. The negative productivity growth would be transient, rather than permanent.

Clearly, the Australian economy has been facing some major structural pressures that have had an adverse effect on measured MFP growth in the 2000s. The difference here is that there has been no apparent productivity payoff. Rather, the payoff is coming in terms of higher prices and higher profit expectations.

This is most prominent in Mining where relative price shifts and increases in profit expectations have been driving very large increases in investment. The Mining sector contributed, by far, the largest expansion in input use. The process of adjustment is essentially to a new productivity *level*, determined by the new set of commodity price expectations. That new productivity level will be determined by the capital capacity that will be installed, the ongoing employment of labour and the output that mines generate.⁷ It will be a lower productivity level than existed before the boom, on the theory that new mines will tend to be focussed on deposits of lower quality. Once the new 'equilibrium' level is reached, further productivity change in the industry will be dictated by the usual interplay of effects from depletion, new discoveries, technological advances and demand and prices at the margin. That is, productivity growth will return to a 'normal' range.⁸

The mining boom could also have had knock-on effects to other industries, such as Manufacturing and Transport.

To the extent that it reflects the mining of less productive deposits, the lower productivity in mining is not of concern to prosperity. The decline does not mean mining operations have become less technically efficient. The deposits may generate less volume of output per unit of input, but they generate sufficient value of output to make the additional inputs worthwhile and to add to prosperity.

The fact that the input accumulation decisions in Mining have been driven by private firms, subject to corporate governance arrangements, gives some confidence

⁷ In a world of high up-front sunk costs, mines tend to operate near full capacity once fully commissioned, so long as variable costs are covered (Topp et al. 2008).

⁸ A collapse in commodity prices would likely see a rise in productivity as the more marginal mines are mothballed.

that the measured MFP decline does not indicate that production resources have been over-allocated to the industry or poorly allocated within it.

Other adverse productivity effects from structural pressures have been highlighted in relation to EGWWS. Additional costs in meeting demands, such as peak summer energy demands, security of supply and mandated technological changes are essentially adjustment costs. They involve a transition to a new lower level of measured productivity, which does not reflect any improvements in output quality. This transition may take some time to work through if, for example, more and more energy generation is to come through higher-cost but lower-emissions sources. Unlike Mining, investment in this industry is not subject solely to private decisions, but is influenced by government policy, regulation and provision. For these reasons, there cannot be the same in-principle confidence about the efficiency of the additional accumulation.

Measurement

It could be said that standard productivity measures do not well handle the kinds of structural adjustments that have been underway in the Australian economy, and especially shifts in the terms of trade. Productivity measures do not take into account:

- the income effects associated with shifts in relative prices and, in particular, the terms of trade
- the lags between investment expenditure and when capital projects start to produce output, such as in Mining and EGWWS
- improvements in the quality of output, such as
 - additional input requirements to meet security of water and energy supply, when there may be little increase in measured units of output
 - mandated changes in technology in pursuit of environmental and quality objectives that are not reflected in output measures
- effects of depletion of an unmeasured input, namely mineral resource deposits
- the effects of weather conditions on production, in particular in Agriculture, but also in Water supply, Mining (and perhaps Construction).

On the other hand, it can be argued that productivity measures should *not* take account of at least some of these complications.

It is not at all clear that price effects should be captured in Mining productivity. Taking income effects into account to allow for terms of trade gains would take productivity measures even further away from being a purely supply-side measure that reflects the efficiency of production. It is true that productivity measures would reflect efficiency in generating income, but efficiency changes would come from the demand side as well as the supply side. Those with an interest in productivity trends would be spared the puzzle that productivity falls when the terms of trade rise, but they might then become puzzled that measured (income-based) productivity falls when the terms of trade fall.⁹

The capital lag effect could warrant some change in method, in this author's view. Capital works in progress are being counted as productive capital before the works are completed and commissioned into production. Work-in-progress should be 'warehoused' in the productivity accounts in inventories until they are completed and they then enter the productive capital stock.

Nevertheless, the significance of this measurement error is related to the magnitude of adjustment underway. The rapid increase in the rate of investment means that the size of the error has been increasing, whereas the error is of little consequence when there is a steady rate of investment (Topp et al 2008).¹⁰

The need for better measures of output that reflect improvements in quality has long been recognised. The case of services is often mentioned and specific cases have been mentioned in this paper. But there may also be some quality issues in Manufacturing output and productivity. Increasingly, Manufacturing outputs have higher value-adding components such as bundled services, specified delivery requirements and products that have a high design element specifically tailored to a customer's requirements.

Security of supply and government-mandated changes in technology could be viewed as quality of output issues. But whether they should be is perhaps contentious. First, in the absence of any information on the value that is put on the quality aspect, such as the security of supply or environmental protection, it is practically difficult to measure the quality improvements. Second, and in principle, it may not be that security of supply and environmental issues are addressed to the appropriate extent or in the most efficient way possible. For example, security of power supply might alternatively be addressed at least in part through some

⁹ There have been proposals to take account of terms of trade effects in productivity measures. See Kohli (2004)

¹⁰ When there is a steady rate of investment, there is also a steady rate of completion and addition to the productive capital stock. There is still the same error from a failure to treat investment initially as work-in-progress, but the consequence of the error is slight.

demand-management mechanisms (such as time-of-day pricing¹¹) that would reduce the additional input requirements to meet demand. Productivity is likely to be higher in this scenario than in the situation where there are no demandmanagement mechanisms. The productivity decline in the latter case has some useful information content. And so, there may be an argument for not taking quality into account unless it is specifically paid for (and the payments made give a basis for measuring quality differences).

4.4 Crisis, adjustment, or both?

Further work is needed to understand all the reasons for Australia's productivity slump over the 2003-04 to 2007-08 cycle.

Nevertheless, it seems clear at a macro level that the usual suspects have played an important role in the slump. In particular, more rapid input accumulation, as part of structural adjustment to a new set of relative prices, has played a major part. This is most readily seen in Mining and EGWWS, but may also be part of the stories in Manufacturing and Transport.

It is impossible to be precise about how much of the slump is due to the usual suspects. But, in order to get a very rough order of magnitude, taking all the Mining contribution and half the Agriculture and EGWWS contributions (to err on the conservative side) yields 0.6 of a percentage point or just over half of the productivity growth decline over the two most-recent cycles.

In addition, since at least some of the combined -0.6 percentage point contribution from Manufacturing and Transport is likely to be the result of structural adjustment, perhaps as much as three quarters of the slump was due to adjustment factors. Some of these factors are inherently transitory, notably drought and the boom in capital investment in response to changes in the terms of trade. Others reflect more fundamental changes such as requirements for improved quality of outputs and depletion effects.

On these rough figures, the *extent* of the slump does not appear to signal that Australia was in a productivity 'crisis'. However, while the usual suspects appear to be the major contributors in the fall in productivity growth over the two most recent cycles, that is not to say that all investments, in particular in mandated technologies, were efficient. Moreover, a better understanding of what has happened in

¹¹ Note also that time-of-day pricing would provide information that would enable the quality differences between energy at peak and non-peak times to be measured.

Manufacturing is needed to complete the picture of just how much the usual suspects were at work.

This conclusion about the importance of the usual suspects does not preclude the possibility that other factors, such as any failure to maintain reforms and reform momentum, had a negative effect on productivity. It is just that their effect would more likely be of the order of a few tenths of a percentage point. Of course, that would still be worth worrying about.¹²

4.5 Further research

This project has indicated some areas where further research is needed. Better understanding of productivity trends in Manufacturing is a pressing priority and is the subject of a current research project at the Productivity Commission. Other industries that warrant further analysis are Transport, postal & storage and Construction. There are various measurement issues that could be explored further (in addition to the capital lag issue): output measurement in Manufacturing, which may be missing some quality improvements, and in Financial & insurance services, which has shown suspiciously-large productivity growth. The reasons for the increase in capital intensity could also be explored. Was this a matter of a compositional shift toward capital-intensive industries, has capital become relatively cheaper, or was there a constraint on growth in labour? An exploration of the sources of profit growth would be of interest. Are some industries extracting some of the resource rents from mining? Are they benefiting from cheaper imports of capital and intermediate goods. Have higher prices and profits been taking away some the imperatives on firms to improve productivity, as Dolman (2009) suggested? Or is it that productivity-sapping regulations have been introduced in a (generally) high-profit environment?

¹² To give some perspective, the MFP gains associated with the use of ICTs in the 1990s were estimated to be of the order of two or three tenths of a percentage point of annual growth (PC 2004).

A Calculating industry contributions

The ABS does not calculate market sector MFP from estimates of industry MFP. Rather, it forms separate indexes of market sector output, total inputs, capital services and hours worked, from which it then forms the market sector MFP estimates.

Moreover, it is not possible to reproduce accurately the market sector MFP estimates from an aggregation of the ABS industry MFP estimates. This is because the ABS uses different methods of aggregation to form the aggregate output and input indexes. And so, there is an 'aggregation problem' in attempting to aggregate industry MFP estimates to the market sector with a single aggregation function. Similarly, market sector MFP growth cannot be attributed to individual industries with precision or consistency.

Consequently, the essence of the ABS aggregation method has been followed in this paper in order to provide more accurate estimates of industry contributions to market sector MFP growth, as published by the ABS.

Another problem that plagues the estimation of industry contributions to aggregate productivity growth over periods such as productivity cycles is about the selection of industry weights — base-period weights, end-period or some average? Whatever the choice, there are inevitable approximation errors between the sum of the industry contributions and the growth in aggregate MFP. Approximation errors have been exacerbated in more recent years by the use of chain volume measures in the data. These effectively update industry weights in aggregate series every year. Growth in chain-volume industry series cannot be aggregated to the corresponding chain-volume market-sector series

The method developed in this appendix also solves these problems.

A.1 Input growth

Total input use is constructed from separate aggregate indexes of capital use and labour use.

Capital use

According to ABS methods, market sector capital services is a Tornqvist aggregation of industry capital services. This is written as:

(A1)
$$\frac{K_{MS}^t}{K_{MS}^{t-1}} = \prod_i \left[\frac{K_i^t}{K_i^{t-1}}\right]^{w_i^{Kt}}$$

Where K is an index of capital services, the subscript *i* refers to industry and MS to the market sector, and the superscript t refers to a specific year. The geometric weight, w^{K} , is an average of capital income shares:

$$w_i^{Kt} = \frac{s_i^{Kt} + s_i^{Kt-1}}{2}$$

where s^{K} is the share that an industry takes in total market sector capital income. The ABS provided unpublished data on industry shares of capital income.

(A1) defines growth in market sector capital services over one year (between t-1 and t) in terms of growth in industry capital services.

Growth over several years, say a three year period, can be defined as follows:

(A2)
$$\frac{K_{MS}^{t}}{K_{MS}^{t-3}} = \frac{K_{MS}^{t}}{KS_{MS}^{t-1}} \cdot \frac{K_{MS}^{t-1}}{K_{MS}^{t-2}} \cdot \frac{K_{MS}^{t-2}}{K_{MS}^{t-3}}$$

Equation (A1) can be substituted in for each of the terms on the right hand side of (A2). Because (A2) is multiplicative, terms for each industry can be gathered, so that the contribution of industry i to growth in market sector capital services over the three years would be:

(A3) Contribution of industry
$$i = \left[\frac{\kappa_i^t}{\kappa_i^{t-1}}\right]^{w_i^{Kt}} \cdot \left[\frac{\kappa_i^{t-1}}{\kappa_i^{t-2}}\right]^{w_i^{Kt-1}} \cdot \left[\frac{\kappa_i^{t-2}}{\kappa_i^{t-3}}\right]^{w_i^{Kt-2}}$$

The growth in market sector capital services is the product of all industry contributions.

The industry contributions can also be expressed in log form. Equation (A1) becomes:

$$ln(K_{MS}^{t}) - ln(K_{MS}^{t-1}) = \sum_{i} w_{i}^{Kt} [ln(K_{i}^{t}) - ln(K_{i}^{t-1})]$$

or,

(A4)
$$k_{MS}^{t(1)} = \sum_{i} w_i^{Kt} k_i^{t(1)}$$

where $k^{t(1)}$ is the growth in capital services over one year to *t*.

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Using (A2) and then (A4), growth over a three-year period can be written:

(A5)
$$k_{MS}^{t(3)} = k_{MS}^{t(1)} + k_{MS}^{t-1(1)} + k_{MS}^{t-2(1)}$$
$$= \sum_{i} w_{i}^{Kt} \cdot k_{i}^{t(1)} + \sum_{i} w_{i}^{Kt-1} \cdot k_{i}^{t-1(1)} + \sum_{i} w_{i}^{Kt-2} \cdot k_{i}^{t-2(1)}$$

The contribution of industry *i* to market-sector growth is:

(A6)
$$w_i^{Kt} \cdot k_i^{t(1)} + w_i^{Kt-1} \cdot k_i^{t-1(1)} + w_i^{Kt-2} \cdot k_i^{t-2(1)}$$

That is, an industry's contribution over three years is the accumulation of its contribution in each of the three years. Whilst this seems totally obvious, it has an important implication. It means that all the share information for individual years is used in calculating industry contributions. This avoids approximation errors that would come from the common and simpler approach of using base-year shares, end-year shares or an average of base-and end-year shares.

Dividing (A5) by 3 (and multiplying by 100) gives the per cent average annual rate of growth over the three-year period. Dividing (A6) by 3 (and multiplying by 100) gives the percentage point contribution of industry i.

Approximation errors

Calculated industry contributions to market-sector capital growth (table 3.2) and industry capital contributions to aggregate MFP growth (table 3.6) accorded very closely with estimates based on aggregate data.

Labour use

A similar approach can be implemented for hours worked. The equivalent of (A1) is:

(A7)
$$\frac{L_{MS}^t}{L_{MS}^{t-1}} = \prod_i \left[\frac{L_i^t}{L_i^{t-1}}\right]^{w_i^{Lt}}$$

where L refers to hours worked and

$$w_i^{Lt} = \frac{s_i^{Lt} + s_i^{Lt-1}}{2}$$

In this case, however, the s^{L} shares are not industry shares in labour income, but are industry shares in total hours worked. These shares are used to give a closer approximation to the ABS procedure of forming an aggregate hours worked index from the sum of hours worked in each industry. The use of shares in hours worked, rather than in labour income, implicitly assumes that the marginal product of an hour worked is equal across industries. This assumption is also implicit in the ABS

procedure of adding hours worked in different industries. The (A7) form of aggregation is used here in order to preserve a basic consistency with the aggregation approach used elsewhere. This enables the construction of contributions tables (chapter 3) in which industry contributions are completely additive.

The industry shares in hours worked were calculated from Labour Force Survey data provided by the ABS. They reflect some adjustments the ABS makes to hours worked and their industry distribution for entry into the productivity accounts (see ABS *Concepts, Sources and Methods*, Cat. no. 5216.0).

Growth in labour use over a year can be written in the equivalent to (A4) as:

(A8)
$$l_{MS}^{t(1)} = \sum_{i} w_i^{Lt} . l_i^{t(1)}$$

Growth over a three-year period in market-sector hours worked can be written in an equivalent to (A5) as:

(A9)
$$l_{MS}^{t(3)} = \sum_{i} w_{i}^{Lt} . l_{i}^{t(1)} + \sum_{i} w_{i}^{Lt-1} . l_{i}^{t-1(1)} + \sum_{i} w_{i}^{Lt-2} . l_{i}^{t-2(1)}$$

and the contribution of industry i to that growth can be written in the equivalent to (A6) as:

(A10)
$$w_i^{Lt} \cdot l_i^{t(1)} + w_i^{Lt-1} \cdot l_i^{t-1(1)} + w_i^{Lt-2} \cdot l_i^{t-2(1)}$$

Again, these can be divided by the number of years to provide annualised growth rates and industry contributions.

Approximation errors

Calculated industry contributions to market-sector hours worked growth (table 3.3) and industry labour contributions to aggregate MFP growth (table 3.6) accorded very closely with estimates based on aggregate data.

Total inputs

The index of total input use is a Tornqvist aggregation of the indexes of capital use and labour use. That is:

(A11)
$$\frac{N_{MS}^t}{N_{MS}^{t-1}} = \left[\frac{K_{MS}^t}{K_{MS}^{t-1}}\right]^{w_{MS}^{Kt}} \cdot \left[\frac{L_{MS}^t}{L_{MS}^{t-1}}\right]^{w_{MS}^{Lt}}$$

where w^{K} and w^{L} are respectively the capital and labour weights, based on shares in total factor income generated in the market sector:

$$w_{MS}^{Kt} = \frac{s_{MS}^{Kt} + s_{MS}^{Kt-1}}{2}$$
 and $w_{MS}^{Lt} = \frac{s_{MS}^{Lt} + s_{MS}^{Lt-1}}{2}$

(A1) and (A7) can then be substituted into (A11) to express growth in market sector total input use in terms of contributions from individual industries.

Going via logs, (A11) can be written as:

(A12)
$$n_{MS}^{t(1)} = w_{MS}^{Kt} \cdot k_{MS}^{t(1)} + w_{MS}^{Lt} \cdot l_{MS}^{t(1)}$$

which, using (A4) and (A8), becomes:

(A13)
$$n_{MS}^{t(1)} = w_{MS}^{Kt} \sum_{i} w_{i}^{Kt} \cdot k_{i}^{t(1)} + w_{MS}^{Lt} \sum_{i} w_{i}^{Lt} \cdot l_{i}^{t(1)}$$

The contribution of industry *i* to the growth in market sector total input use is:

(A14)
$$W_{MS}^{Kt}.w_i^{Kt}.k_i^{t(1)} + w_{MS}^{Lt}.w_i^{Lt}.l_i^{t(1)}$$

(A14) expresses the industry contribution as a combination of a capital component and a labour component.

Growth over a number of years can be expressed in the same manner as set out separately above for capital and for labour. These expressions also identify the industry contributions to growth over a period of years.

Approximation errors

With no appreciable approximation errors in capital and labour, there are similarly no appreciable approximation errors in total inputs tables 3.1 and 3.6.

A.2 Output growth

The same format is used for output.

(A15)
$$\frac{Y_{MS}^{t}}{Y_{MS}^{t-1}} = \prod_{i} \left[\frac{Y_{i}^{t}}{Y_{i}^{t-1}} \right]^{w_{i}^{Yt}}$$

where Y refers to value added and

$$w_i^{Yt} = s_i^{Yt-1}$$

where s^{Y} refers to shares in current price output.

The geometric weight is set equal to the base period output share to replicate the ABS practice of using a Laspeyres index to aggregate outputs. The current price

output shares were derived by the author from National Accounts data (ABS Cat. No. 5204.0)

With this formulation, now familiar relationships in terms of industry growth and industry contributions fall out.

(A16)
$$y_{MS}^{t(1)} = \sum_i w_i^{Yt} \cdot y_i^{t(1)}$$
.

The contribution of industry *i* to this growth in market sector output is w_i^{Yt} . $y_i^{t(1)}$.

Market sector growth over a three-year period is:

(A17)
$$y_{MS}^{t(3)} = \sum_{i} w_{i}^{Yt} \cdot y_{i}^{t(1)} + \sum_{i} w_{i}^{Yt-1} \cdot y_{i}^{t-1(1)} + \sum_{i} w_{i}^{Yt-2} \cdot y_{i}^{t-2(1)}$$

and the contribution of industry *i* to that growth is:

(A18)
$$w_i^{Yt}.y_i^{t(1)} + w_i^{Yt-1}.y_i^{t-1(1)} + w_i^{Yt-2}.y_i^{t-2(1)}$$

Approximation errors

Table 3.4 indicates discernible approximation errors, especially in regard to the first productivity cycle. Examination of annual approximations suggests that there may be a greater problem specifically in the 1993-94 year than in other years around that time.

There was insufficient time to track down the sources of the errors. The fact that the errors were greater in earlier periods and before 1994-95 may have something to do with the greater consistency that has been provided by supply-use tables from 1994-95.

A.3 MFP growth

MFP is calculated as the ratio of the output index to the index of total input use. MFP growth can be expressed in the format used for the input and output components in this appendix.

(A19)
$$\frac{{}^{MFP}{}^{t}_{MS}}{{}^{MFP}{}^{t-1}_{MS}} = \left[\frac{Y^{t}_{MS}}{Y^{t-1}_{MS}}\right] \cdot \left[\frac{N^{t}_{MS}}{N^{t-1}_{MS}}\right]^{-1}$$

(A15) and (A11) can then be used to express the right-hand-side in terms of industry growth in output and inputs.

Similarly, (A19) can be expressed as:

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(A20)
$$mfp_{MS}^{t(1)} = y_{MS}^{t(1)} - n_{MS}^{t(1)}$$

or, using (A16) and (A13):

(A21)
$$mfp_{MS}^{t(1)} = \sum_{i} w_{i}^{Yt} \cdot y_{i}^{t(1)} - w_{MS}^{Kt} \cdot \sum_{i} w_{i}^{Kt} \cdot k_{i}^{t(1)} - w_{MS}^{Lt} \cdot \sum_{i} w_{i}^{Lt} \cdot l_{i}^{t(1)}$$

and the contribution of industry *i* is:

(A22)
$$w_i^{Yt}. y_i^{t(1)} - w_{MS}^{Kt}. w_i^{Kt}. k_i^{t(1)} - w_{MS}^{Lt}. w_i^{Lt}. l_i^{t(1)}$$

Market sector MFP growth over a three-year period is the accumulation of (A21) over three years:

$$\begin{split} mfp_{MS}^{t(3)} &= \sum_{j=0}^{2} \left[\sum_{i} w_{i}^{Yt-j} . y_{i}^{t-j(1)} - w_{MS}^{Kt-j} . \sum_{i} w_{i}^{Kt-j} . k_{i}^{t-j(1)} \right. \\ &\left. - w_{MS}^{Lt-j} . \sum_{i} w_{i}^{Lt-j} . l_{i}^{t-j(1)} \right] \end{split}$$

The contribution of industry *i* to the three year growth is (A22) plus (A22) implemented for *t*-1, plus (A22) implemented for *t*-2.

Approximation errors

The approximation errors in output carry over into approximation errors in MFP (table 3.5).

B Structural change between industries

Examination of the role of structural change in economic development and growth has a long history. To convey the breadth and depth of this work succinctly is difficult. As just an example of the work, there has been extensive analysis of the effects on aggregate productivity that come through the reallocation of resources from low-productivity to high-productivity industries (from agriculture to other industries in low-income countries), or the other way round (from manufacturing to services in high-income countries).¹

'Shift-share' analysis, in various forms, has been the empirical 'workhorse' in this area. Growth in aggregate productivity is decomposed into a 'fixed-structure' component, which isolates effects that arise *within industries*, and a 'reallocation' component, which reflects structural change or the reallocation of activity and inputs *between industries* at fixed productivity levels.

Industry analysis has focussed on labour productivity, rather than MFP. The tractability of measuring the level of productivity, needed to compute the reallocation component, is the obvious reason. Labour productivity can be uniquely determined from data on output and employment or hours worked. MFP, on the other hand, is determined in index form and its level in any year is sensitive to the base year selected.

Decompositions of MFP growth have entered the burgeoning literature on empirical analysis of firm-level productivity.² It is not clear, however, that analysts have solved the 'base-period problem'. Preliminary analysis for this project using MFP methodologies drawn from the firm-level literature indicated that sensitivity to selection of base period for MFP indexes remains an issue.

The problem centres on measuring the 'between industries' reallocation effect. This requires a measure of the level of productivity in each industry. The 'between'

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¹ The former effect is sometimes referred to as the 'Lewis effect' after the 1950s dual economy work of W. Arthur Lewis and the latter effect is often referred to as the 'Baumol effect' after the 1960s work of William Baumol (for discussion and references see, for example, van Ark and Timmer 2003).

² See Foster, Haltiwanger and Krizan (2001) for a review.

component of aggregate productivity growth comes about as the collection of changes in industry size at a fixed productivity level.

The problem has been circumvented for this study in the following way. Especially in firm-level studies, the aggregate productivity growth to be decomposed is defined as the sum of the 'within' and 'between' components. An independent measure of aggregate productivity does not exist. Here, however, an independent measure of aggregate productivity, expressed in terms of industry contributions, does exist. The method for deriving it is set out in appendix A. A meaningful 'within-industry' component can be constructed, as is demonstrated in this appendix. The 'betweenindustry' component can therefore be derived as a residual — the difference between the total or aggregate productivity growth and the 'within' component.

Methods for deriving 'within' and 'between' components are set out in the next section. The 'within' and 'between' industry components are derived for the three productivity cycles of interest in the third section.

B.1 Decomposition formulas

A single standard approach to structural decomposition of productivity growth has not emerged, even though there has been a long history of analysis in this area. Some researchers have developed different elaborations of decomposition formulas and, at times, have attracted controversy in doing so. Some studies have decomposed labour productivity growth, while others have decomposed MFP growth, but formulas cannot always be applied in the same way to one form of productivity or the other — a limitation that does not always seem to be recognised.

The approach taken here is to take a lead from the more recent firm-level empirical literature, and apply it to the case of structural change across industries. The lead is taken from a review and analysis by Foster, Haltiwanger and Krizan (2001), which has become an authoritative piece in the firm-level empirical literature. The 'entry' and 'exit' part of firm-level decomposition formulas can be dropped for this purpose. With the broad industry groupings used in this paper, all industries continue in existence throughout the period examined and none enter or exit. And so, only the 'continuing firms' part of formulas applies.³

The starting point is to express the way in which aggregate productivity relates to productivity in its constituent industries — that is, the productivity 'aggregator

³ Formulas for decomposing MFP growth are derived. While the same general approach can be used for labour productivity, there are important differences in detail. However, there is no need to set them out here.



function'. Aggregate MFP (for the market sector in this context) is taken to be a geometric average of the productivities in industries. That is:

$$MFP_{MS}^t = \prod (MFP_i^t)^{s_i^{Yt}}$$

where *MFP* refers to indexes of multifactor productivity, the subscript *i* refers to industry, the subscript *MS* refers to the market sector and the superscript *t* refers to time. The s^{Y} refers to industry shares in market sector output.

This specification of the aggregator function is often used in firm-level studies, although it is usually expressed in log form (see Foster, Haltiwanger and Krizan 2001) as follows:

$$\ln(MFP_{MS}^{t}) = \sum s_{i}^{Y_{t}} . \ln(MFP_{i}^{t})$$

For notational ease, this can be expressed as:

(B1)
$$P_{MS}^t = \sum s_i^{Yt} \cdot P_i^t(1)$$

The *growth* in MFP between *t*-*n* and *t* can be measured as the difference in logged values of MFP in *t*-*n* and t.⁴ The growth in market sector MFP is therefore:

(B2)
$$\Delta P_{MS}^{t(n)} = \sum s_i^{Yt} \cdot P_i^t - \sum s_i^{Yt-n} \cdot P_i^{t-n}$$

The various decomposition methods transform (B2) in different ways. The common essential feature, however, is that they decompose aggregate productivity growth (the left hand side) into a 'within' (industries) component — the aggregate productivity growth that comes about via growth in industries' productivity, with the relative size of industries fixed — and a 'between' (industries) component — the aggregate productivity growth that comes about via reallocation of activity among industries with industries' productivity fixed.

A decomposition based on Foster, Haltiwanger and Krizan

The methodology of Foster, Haltiwanger and Krizan (2001) — hereafter referred to as FHK — is one approach. The part of the FHK approach that applies to entering and exiting firms can be dropped in this application to the case of industries.

⁴ Note this is the rate of growth over the *n*-year period. The average annual rate of growth would be found by dividing by the number of years, *n*.

The first step is to add and subtract $\sum s_i^{\gamma_t - n} P_i^t$ to the right hand side of (B2), which obviously has no net effect on the equation. With regrouping of terms, this yields:

(B3)
$$\Delta P_{MS}^{t(n)} = \sum s_i^{t-n} \Delta P_i^{t(n)} + \sum P_i^t \Delta s_i^{Yt(n)}$$

The first term on the right hand side is the 'within' effect — the sum of changes in industries' productivity at fixed (base period) shares.⁵ The within effect on aggregate productivity growth is positive if the weighted sum of the productivity growth in productivity-improving industries outweighs the weighted sum of the (negative) productivity growth in industries with poorer productivity performance. This is more likely to be the case if, for example, large industries improve their productivity.

The second term is the 'between' effect — the sum of changes in industries' shares multiplied by their new (end period) level of productivity. The between effect is positive if the reallocation of activity is biased toward industries with higher levels of productivity.

FHK added a covariance term, which can be derived by adding and subtracting the terms $\sum s_i^{y_t} P_i^t$ and $\sum s_i^{y_{t-n}} P_i^t$ to equation (B3):

$$\begin{split} \Delta P_{MS}^{t(n)} &= \sum s_i^{Y_{t-n}} \Delta P_i^{t(n)} + \left[\sum s_i^{t} P_i^{t-n} - \sum s_i^{Y_{t-n}} P_i^{t-n} \right] \\ &+ \left[\sum s_i^{Y_{t}} P_i^{t} - \sum s_i^{Y_{t}} P_i^{t-n} - \sum s_i^{Y_{t-n}} P_i^{t} + \sum s_i^{Y_{t-n}} P_i^{t-n} \right] \end{split}$$

Grouping the terms in brackets:

(B4)
$$\Delta P_{MS}^{t(n)} = \sum s_i^{t-n} \Delta P_i^{t(n)} + \sum P_i^{t-n} \Delta s_i^{t(n)} + \sum \Delta P_i^{t(n)} \Delta s_i^{t(n)}$$

This formulation splits the between-industries effect into two components. The second term in (B4) is sometimes referred to as the 'static reallocation' component — the growth in aggregate productivity due to the reallocation of activity between industries (that is, changes in shares) at fixed industry productivity levels. The third term is sometimes referred to as the 'dynamic' reallocation effect — the growth in aggregate productivity due to the combination of industry productivity growth and reallocation of activity. The dynamic effect is positive when productivity growth in expanding industries dominates.

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⁵ Equation (B3) is the equivalent of the 'continuing firms' part of the Baily, Hulten and Campbell (1992) decomposition.

FHK introduced one further modification. They expressed the static reallocation effect in terms of deviations in productivity from the average (here, the market sector average). This can be introduced into equation (4) by subtracting $P_{MS}^{t-n} \sum s_i^{Yt}$ and adding $P_{MS}^{t-n} \sum s_i^{Yt-n}$. Because the sum of the shares is equal to unity in both cases, this is effectively adding and subtracting the same amount, and so equation (B4) still holds. It becomes:

(B5)
$$\Delta P_{MS}^{t(n)} = \sum s_i^{Yt-n} \Delta P_i^{t(n)} + \sum (P_i^{t-n} - P_{MS}^{t-n}) \Delta s_i^{t(n)} + \sum \Delta P_i^{t(n)} \Delta s_i^{t(n)}$$

The static reallocation effect then has the interpretation that industries have a positive effect on aggregate productivity growth if they expand and their productivity levels are above average — or if their share shrinks and their productivity is below average. Similarly, industries will have a negative static reallocation effect if they have below-average productivity and they grow relatively rapidly (and conversely).

Industries will have a positive effect on aggregate productivity growth through the dynamic reallocation effect if they grow relatively rapidly and at the same time improve their productivity (and conversely). Negative dynamic reallocation contributions arise when industries grow relatively fast (slow) and at the same time reduce (increase) productivity.

A decomposition based on Griliches and Regev

FHK also put forward a 'method 2' decomposition formula in their review and analysis. It is closely related to the formula proposed by Griliches and Regev (1995).

Once again, the derivation with respect to industries is drawn from the 'continuing firms' part of the specification.

First, equation (B2) is rewritten as:

$$\Delta P_{MS}^{t(n)} = \frac{1}{2} \sum s_i^{Y_t} P_i^t - \frac{1}{2} \sum s_i^{Y_t - n} P_i^{t - n} + \frac{1}{2} \sum s_i^{Y_t} P_i^t - \frac{1}{2} \sum s_i^{Y_t - n} P_i^{t - n}$$

Now add and subtract the same additional terms, $\frac{1}{2}\sum s_i^{Y_{t-n}}P_i^t$ and $\frac{1}{2}\sum s_i^{Y_t}P_i^{t-n}$ so that there is no net effect on the equation:

$$\Delta P_{MS}^{t(n)} = \frac{1}{2} \sum S_i^{Y_t} P_i^t + \frac{1}{2} \sum S_i^{Y_{t-n}} P_i^t - \frac{1}{2} \sum S_i^{Y_t} P_i^{t-n} - \frac{1}{2} \sum S_i^{Y_{t-n}} P_i^{t-n}$$

$$+\frac{1}{2}\sum_{i} s_{i}^{Y_{t}} P_{i}^{t} + \frac{1}{2}\sum_{i} s_{i}^{Y_{t}} P_{i}^{t-n} - \frac{1}{2}\sum_{i} s_{i}^{Y_{t-n}} P_{i}^{t} - \frac{1}{2}\sum_{i} s_{i}^{Y_{t-n}} P_{i}^{t-n}$$

Rearranging:

$$\Delta P_{MS}^{t(n)} = \sum \frac{(s_i^{Y_{t-n}} + s_i^{Y_t})}{2} P_i^t - \sum \frac{(s_i^{Y_{t-n}} + s_i^{Y_t})}{2} P_i^{t-n}$$
$$+ \sum \frac{(P_i^{t-n} + P_i^t)}{2} S_i^t - \sum \frac{(P_i^{t-n} + P_i^t)}{2} S_i^{t-n}$$

and so

(B6)
$$\Delta P_{MS}^{t(n)} = \sum_{i} s_i^{\gamma_a} \Delta P_i^{t(n)} + \sum_{i} P_i^a \Delta s_i^{\gamma_t(n)}$$

where *a* is the arithmetic average of values in *t*-*n* and t.⁶

As before, FHK introduced a modification to highlight differences in productivity in firms (industries here) from the average. Subtracting $P_{MS}^a \sum s_i^{\gamma_{t-n}}$ and adding $P_{MS}^a \sum s_i^t$, which is net zero because the sum of shares in both cases is unity, the equation becomes:

(B7)
$$\Delta P_{MS}^{t(n)} = \sum_{i} s_{i}^{a} \Delta P_{i}^{t(n)} + \sum_{i} (P_{i}^{a} - P_{MS}^{a}) \Delta s_{i}^{t(n)}$$

With this method, the 'within' effect comprises the same growth in industry productivity as in the FHK method, but weighted at the average of shares in the base and end periods (rather than at the base period shares). The 'between' effect collapses into a single term, with an interpretation similar to the static reallocation effect in the FHK method, except that the measurement of the extent to which industries deviate from the market-sector average level of productivity is based on the arithmetic averages of base- and end- period values.

In the firm-level empirics literature, the use of average values in the GR method is considered to carry some advantage in that it reduces the sensitivity of measured 'within' and 'between' effects to random measurement errors in some years (Foster, Haltiwanger and Krizan 2001, p.317).

⁶ This is the 'continuing firms' formulation presented by Griliches and Regev (1995).

B.2 Calculation of 'within' and 'between' industry effects

The method now used to calculate within and between industry effects is straightforward.

First, the 'total' industry effects are calculated in accordance with the method set out in appendix A, as an approximation to the growth in market-sector MFP published by the ABS. These estimates are displayed in table B.1.

Second, the within effects are calculated according to the Griliches and Regev method set out in the previous section of this appendix.⁷ However, the simple weighting by output shares, as set out in the previous section is not used. Rather the separate use of output and input weights, as set out in appendix A, is adapted to the task here. In other words, average output shares and average input shares are used as appropriate to calculate the within industry effects. These estimates are also displayed in table B.1.

Third, the between industry effects are calculated as the difference between the total industry effects and the within industry effects. The results are also displayed in table B.1.

Generally, the between industry effects are very small. However, the shift of resources into Mining in the last productivity cycle took one tenth of a percentage point off market sector productivity growth. That is, MFP growth would have been one tenth of a percentage point higher if the Mining industry had not attracted any more resources in the last cycle. This negative effect is some combination of a short-term phenomenon, pending an output response, and a price effect—bringing a lift in income without an output response.

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⁷ The use of average share weights fits with the concept of 'pure' productivity change suggested by, for example, Fox (2004) and Breunig and Wong (2008).

	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08
Published market sector	2.1	1.0	-0.3
Approximation error	0.3	0.1	-0.1
Total industry			
Agriculture	0.19	0.17	-0.06
Mining	0.02	-0.01	-0.48
Manufacturing	0.15	0.30	-0.25
EGWWS	0.06	-0.08	-0.17
Construction	0.27	0.03	0.07
Wholesale trade	0.45	0.12	0.03
Retail trade	0.14	0.05	-0.05
Accommodation & food	0.02	0.01	0.01
Transport, post & storage	0.19	0.14	0.03
Info media & telecomms	0.18	-0.05	-0.01
Financial & insurance	0.19	0.16	0.67
Arts & recreation	-0.03	0.02	-0.04
Market sector	1.8	0.9	-0.2
Within effect			
Agriculture	0.21	0.27	-0.06
Mining	0.02	0.01	-0.36
Manufacturing	0.14	0.29	-0.25
EGWWS	0.06	-0.09	-0.18
Construction	0.27	0 11	0.08
Wholesale trade	0.45	0.12	0.02
Retail trade	0.14	0.05	-0.05
Accommodation & food	0.01	0.01	0.01
Transport, post & storage	0.18	0.14	0.03
Info media & telecomms	0.18	-0.06	-0.01
Financial & insurance	0.18	0.19	0.69
Arts & recreation	-0.03	0.02	-0.04
Market sector	1.8	1.1	-0.1

Table B.1 Total, within and between industry effects

per cent per annum and percentage points

(continued on next page)

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	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08
Between effect			
Agriculture	-0.01	-0.10	-0.01
Mining	-0.01	-0.02	-0.11
Manufacturing	0.00	0.00	0.00
EGWWS	0.00	0.00	0.00
Construction	0.00	-0.07	0.00
Wholesale trade	0.00	0.00	0.01
Retail trade	-0.01	0.00	0.00
Accommodation & food	0.00	0.00	0.00
Transport, post & storage	0.01	0.00	0.00
Info media & telecomms	0.00	0.01	0.00
Financial & insurance	0.00	-0.02	-0.02
Arts & recreation	0.00	0.00	0.00
Market sector	0.0	-0.2	-0.1

## Table B.1 (continued)

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