The Australian multi-factor productivity growth illusion

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Abstract

Multi-factor productivity growth is widely discussed in the media and among policymakers in Australia. Over the past decade it has been predominantly negative often leading to the view that there is a 'productivity crisis.' It is shown that such a measure is wholly misleading. Preliminary econometric investigation suggests that it is economies of scale and scope that are the primary drivers of productivity growth in Australia. However, much more research needs to be undertaken, with the inter-related processes of innovation and entrepreneurship at its core, before any new policies to promote productivity growth are designed and implemented.

1. Introduction

In Australia, there is a prevailing view that there is a productivity crisis. This is based upon observation that multi-factor productivity (MFP) growth estimates have been negative in most years since 2002. This has led to pleas for policies aimed at increasing productivity. But what these often tend to boil down to are calls for a policy to cut the wages of low income employees. The notion that there is a productivity crisis is something of a puzzle because average labour productivity growth over 2011, 2012 and 2013, reached a rate not seen since the 1990s. A further puzzle lies in the estimates of capital productivity growth as reported by the Productivity Commission (PC). They have been negative for a decade with the level of measured capital productivity in 2013 about 20% lower than it was back in 1990 (Productivity Commission (2013) p.3).

Commentators have pointed to two possible explanations of these puzzles. First, it is argued that large capital investments, mainly in the mining sector, have taken a long time to have their full effect on GDP. However, the decline in capital productivity, as reported by the PC, was occurring well before the mining investment boom gathered pace. Second, some argue that there has been a widespread failure by management to invest in and use capital goods effectively (Bloom *et al (*2012)). This is related to a broader argument that Australia has been relatively poor at innovation, in comparison with other OECD countries (Cutler (2008)), and that this is reflected in the observation of negative MFP growth. But how realistic is it to suppose that, over the past decade, Australians have been both bad at investing in capital goods and so bad at innovating that MFP growth has been negative? This all seems counterintuitive in an economy with one of the OECD's strongest growth records and the absence of a recession for 22 years.

Can we really draw any inferences, as does Parham (2013), from the estimates of MFP growth produced by the Australian Bureau of Statistics (ABS) and employed by the PC in their regular Updates on productivity growth? The PC fully acknowledges that there are problems with the methodology that is applied (see Productivity Commission (2013), pp.11-12).[1] However, this does not prevent it from publishing estimates of MFP growth, not only for GDP but also for 16 different industries. Since these estimates set the scene for national discussions concerning policies to stimulate productivity, it is very important to establish that they are robust. So, the goal of this paper is straightforward: using a very simple approach, the validity of the ABS/PC methodology is assessed and conclusions are drawn.

2. Estimates of multi-factor productivity growth: where do they come from?

Both the ABS and the PC use estimates of MFP growth that are a product of 'growth accounting.' This is explained in Productivity Commission (2013) p. 4. What is not made clear is the set of very restrictive assumptions that are made to obtain such estimates. The methodology used can be traced back to Solow (1957) and builds upon the notion that an aggregate production function is a meaningful construction. The production function posited by the ABS contains the net capital stock, as a proxy for capital services, and labour hours as a proxy for labour services. This aggregate production function is assumed to be of the Cobb Douglas form which means that constant returns to scale are imposed and that both factors of production receive the value of their marginal products. This implies, in turn, that 'perfect competition' exists (see Australian Bureau of Statistics (2007)). These assumptions enable the profit and wage shares of GDP to be

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[1] What the PC does not discuss is the validity of its methodology given the widely acknowledged problems, both theoretically and empirically, involved in using an aggregate measure of capital (Cohen and Harcourt (2003)).

equated with the exponents on the capital stock and labour hours, respectively, in a Cobb-Douglas specification. Some simple accounting can then be used to derive MFP growth for any selected period.

In reality, none of the restrictive assumptions made are likely to hold, especially when we are dealing with the long periods over which economic growth is studied. However, it is argued that the methodology provides a useful approximation. This reflects an 'instrumentalist' perspective on methodology: useful theory need not be realistic if the goal is prediction rather than explanation. And, indeed, there is no 'explanation' involved in the estimation of the growth of MFP as a residual in an accounting exercise. But the resultant empirical estimates are not used for prediction either so it is not clear what the purpose of the exercise is. Prediction would require time series modelling but neither in Australian Bureau of Statistics (2007) nor Productivity Commission (2013) offer econometric evidence, using historical data, that supports the Cobb-Douglas growth model applied.

It is clear that the calculation of MFP growth depends heavily upon the presumption of constant returns to scale inherent in the Cobb-Douglas specification. This tends to be understated and loosely discussed. For example, on Page 5 of Productivity Commission (2013), it is asserted that some of MFP growth can be attributed to "economies of scale". But this does not make sense. It is well known that, when there are economies of scale, a Cobb-Douglas specification cannot be used because, when there are economies of scale, the exponents on capital and labour must sum to greater than unity. So, if there are, indeed, economies of scale and a Cobb-Douglas production function is assumed in order to use factor income shares, then the estimates of MFP growth must, by definition, be incorrect.[2]

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[2] See Felipe and McCombie (2013) for an extended discussion of the problems of measuring technical change using aggregate production functions.

And, indeed, the negative growth in MFP from about 2002 on, reported in, for example, Productivity Commission (2013) p.3, is likely to be in error because it implies that technical innovations, plus a range of other forms of innovation over the past decade, have had *negative* impacts on economic growth. This is very hard to believe. Also, the observed large fall in 'capital productivity' is also counter intuitive. It may well be true that some gestation lags in capital investments in the natural resources sector have been factors in lowering it but, as noted above, the decline occurred before the mining investment boom. Typically, new capital goods are increasingly productive, as new models come on the market over time. Also, they generally replace old capital goods that are much less productive. So falling capital productivity implies that there has been serious mismanagement of physical capital in productive organisations. This seems very unlikely, despite apocryphal tales about firms buying computers and not knowing what to do with them! It is much more likely that there is a fundamental error in the methodology used to derive productivity growth estimates. This we can examine quite simply.

3. A simple test of the validity of MFP growth estimates

On page 4 of Productivity Commission (2013), the standard Solow growth model, with factor shares of GDP replacing Cobb-Douglas exponents, is specified in Eq. (1). It can be rewritten in first differences *(d)* of natural logarithms *(ln)*:

$$dlnGDP_t \quad = \quad a\ dlnK_t \ + \ b\ dlnL_t + MFPG_t \ + \ u_t \qquad (1)$$

where: **GDP** is gross domestic product

K is the net capital stock (approximating capital services)

L is total hours worked (approximating labour services)

MFPG is multifactor productivity growth

Eq. (1) is an accounting identity in any year. However, it is not if we are estimating the relationship over time so an error term u is included in Eq. (1). The period selected is 1965-2004 because this matches the time period over which DCITA (2005) provided a consistent multi-factor productivity index time series constructed by the ABS. If an aggregate Cobb Douglas production function is used in each year to compute **MFPG** then we would predict that the sum of the estimated coefficients on **K** and **L** to be unity and that on estimated **MFPG** should also be around unity. Different coefficients are obtained for **a** and **b** in each year so econometric estimation using time series data discovers average values of these coefficients with variations consigned to the statistical error term, as is usual in regression analysis. Since it is presumed by the ABS that technical progress is Hicks neutral, there must be no embodied technical change in capital or labour that shifts these coefficients.

Now, we know that the ABS used growth accounting to estimate **MFPG** year by year, using the prevailing shares of capital and labour in GDP. An alternative set of measures of marginal factor productivity were constructed by Erwin Diewert and Denis Lawrence and reported in DCITA (2005). Following their terminology, it is labelled **TFPG.** It is clear from Table 1 that their estimates, derived from growth accounting, do, indeed, yield the predictions above.

Table 1

Dependent Variable: **$dlnGDP_t$**

Sample: 1966 2004 (39 observations)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$dlnK_t$	0.271	0.002	108.592	0.000
$dlnL_t$	0.729	0.004	199.799	0.2952
$DLTFP_t$	0.998	0.002	412.994	0.000
R-squared	0.999	Mean dependent var		0.037
Adjusted R-squared	0.999	S.D. dependent var		0.025
Durbin-Watson	0.886			

Table 2

Dependent Variable: **dlnGDP$_t$**

Sample: 1966 2004 (39 observations)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
dlnK$_t$	0.862	0.148	5.833	0.000
dlnL$_t$	0.173	0.234	0.739	0.465
DLMFP$_t$	-0.102	0.199	-0.514	0.610
R-squared	-0.069	Mean dependent var		0.037
Adjusted R-squared	-0.129	S.D. dependent var		0.025
Durbin-Watson	2.166			

However, when we substitute the ABS measure of **MFPG** for **TFPG** the relationship completely collapses (Table 2). In other words there is no relationship whatsoever between these estimates, both drawn from growth accounting exercises. Multi-factor productivity growth enters with a negative sign and, the **R^2**, when one is regressed on the other, is only 0.036. The total lack of correspondence of these two measures of MFP calls into question their usefulness in understanding productivity growth starting with accounting identities and strong assumptions concerning the Cobb-Douglas form of the aggregate production function and constant returns to scale.

Table 3

Dependent Variable: **dlnGDP$_t$**

Sample: 1966 2004 (39 observations)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.030	0.015	2.030	0.050
dlnK$_t$	0.159	0.374	0.424	0.674
dlnL$_t$	0.151	0.225	0.670	0.507
DLMFP$_t$	-0.185	0.195	-0.951	0.348
R-squared	0.043	Mean dependent var.		0.037
Adj. R-squared	-0.039	S.D. dependent var.		0.025
DurbinWatson	1.984			

Interestingly, the growth of the capital stock remains significant but introducing a constant, as should be done when the R-squared is negative, removes all its statistical significance (Table 3).

In publications by the Productivity Commission, in general discourse in the media and amongst policymakers, multi-factor productivity growth is viewed as a solid and reliable indicator of productivity growth. There is no need to move beyond these simple regression results to conclude that any estimates of multi-factor productivity growth using the standard growth accounting methods are not credible and, thus, highly dangerous to base policies upon. So, can we say anything at all about productivity growth using simple econometrics?

4. Are there really constant returns to scale?

Diewert and Fox (2008) found strong evidence that economies of scale are much more important than multi-factor productivity growth in the US. In other words, constant returns to scale do not hold, nor does the assumption of perfect competition. With regard to the latter, they presume that imperfect competition with mark-up pricing exists, which is much more realistic.

Without departing very far from Eq. (1), we can begin to explore, in a preliminary way, if Australia is similar. If increasing returns to scale exist, in Eq. (1), *a* and *b* should sum to greater than unity. But Table 2 seems to suggest that there is very little to discuss in this regard. To make some progress, let us specify the GDP growth relationship a little more realistically.

First of all, there has been some debate concerning the most appropriate measure of GDP growth to use in econometric research covering decades before 1990. Snooks (1994) argued that the available ABS estimates, such as those used in the DICITA (2005) study, are incomplete particularly when we go further back in history. Measurement errors have a particularly marked effect on growth data so the Snooks (1994) data on GDP (**GDPS**) *is* preferred up to 1990 with ABS data employed for the remaining 14 years, w hen differences in estimates are likely to be much less. In Table 4 we can see

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that GDP is better explained, compared to Table 3, with both labour hours growth and capital stock growth significant at the 5% and 10% levels, respectively. It is striking that, with *a* and *b* summing to 1.48, there is support for the hypothesis that economies of scale are present. There is no sign of an average MFP growth effect, however.

Table 4

Dependent Variable: $dlnGDPS_t$

Sample (adjusted): 1966 2004 (39 observations)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.002	0.017	-0.136	0.892
$dlnL_t$	0.707	0.263	2.685	0.011
$dlnK_t$	0.774	0.440	1.759	0.087

R-squared		0.254	Mean dependent var	0.039
Adjusted R-squared		0.212	S.D. dependent var	0.033
F-statistic		6.128	Durbin-Watson stat	1.171

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Secondly, it makes little sense to have a specification including only contemporaneous growth rates. It has been widely acknowledged that there are significant lags before the full impact of capital investment is felt on economic growth. This is less likely in the case of increases in labour hours but a lag may still be present. Training and learning from experience, particularly using new kinds of capital goods, take time. Keeping things as simple as possible since we are only modelling here for illustrative purposes, rather than, definitively, a very simple partial adjustment model can be employed as follows:

$$GDPS^* = AL^{\alpha}K^{\beta}e^{\lambda t} \tag{2}$$

Where ***** denotes a long run equilibrium value

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Therefore:

$$lnGDPS_t^* \qquad = \qquad (lnA + \lambda t) + \alpha lnL_t + \beta lnK_t \qquad\qquad (3)$$

Where: $GDPS_t^*$ is fully adjusted gross domestic product

lnA is a constant and λ is the average rate of multi-factor productivity growth in the

chosen sample period

With slow adjustment:

$$lnGDPS_t - lnGDPS_{t-1} = c[lnGDPS_t^* - lnGDPS_{t-1}] \qquad\qquad (4)$$

Where: $c < 1$

Therefore:

$$lnGDPS_t = \qquad c[(lnA + \lambda t) + \alpha lnL_t + \beta lnK_t] + (1-c)lnGDPS_{t-1} \qquad\qquad (5)$$

First differencing:

$$dlnGDPS_t \qquad = \qquad c\lambda + c\alpha dlnL_t + c\beta dlnK_t + (1-c)dlnGDPS_{t-1} + u_t \qquad\qquad (6)$$

Where: u_t is assumed to be a randomly distributed error term included for estimation purposes.

However, although the partial adjustment hypothesis allows for lags in adjustment, it is overly

restrictive in the sense that it does not allow for differential delay in the impact of different

independent variables. For example, capital services consumed in construction and installation do

not begin to yield output until a project is complete. Only then will the exponential adjustment path

of output be followed. To allow for this possibility, three test lags were included for each

independent variable in addition to their contemporaneous values.

Another modification is made in relation to the measurement of capital services flow. In addition to

being difficult to measure accurately, the capital stock is a poor proxy for the flow of consumed

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capital services. For example, this is discussed extensively in Productivity Commission (2013) in the context of business cycles. An alternative proxy for the consumption of capital services is energy consumption which is highly complementary with the former in a modern economy. So **K** is replaced by **E** (energy consumption) in Eq. (6). [3]

$$dlnGDPS_t = c\lambda + c\alpha(dlnL_{t-1}...dlnL_{t-3}) + c\beta(dlnE_{t-1}...dlnE_{t-3}) + (1-c)dlnGDPS_{t-1} + u \qquad (7)$$

Eq. (7) was estimated and 'general-to-specific' elimination was applied to obtain a parsimonious representation. As a check, growth of the capital stock was kept in the estimating equation with the same number of lags. All were insignificant and eliminated. The results are reported in Table 5.

Table 5

Dependent Variable: **$dlnGDPS_t$**

Sample (adjusted): 1968 2004 (37 observations)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$c\lambda$	-0.006	0.009	-0.683	0.499
$dlnL_t$	0.689	0.215	3.204	0.003
$dlnE_{t-2}$	0.523	0.216	2.415	0.021
$dlnGDPS_{t-1}$	0.445	0.122	3.655	0.001

R-squared	0.555	Mean dependent var.	0.038
Adjusted R-squared	0.515	S.D. dependent var	0.034
F-statistic	13.743	Durbin-Watson stat	1.472

Introducing adjustment dynamics and differential delay in simple ways leads to a marked improvement in explanatory power. The constant term is insignificant indicating the absence of an average rate of multi-factor productivity growth. The sum of **a** and **b** is 1.85 with full adjustment, supporting the hypothesis that strong economies of scale are present. Inclusion of the growth of energy consumption as a proxy for the flow of capital services is significant with a two year delay

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[3] See Foster (2014) for extended discussion of energy consumption as a measure of the flow of capital services and why the capital stock is best viewed as a repository of technical knowledge.

supporting the hypothesis that it takes some time before energy consumption used in construction and installation begins to yield output.[4]
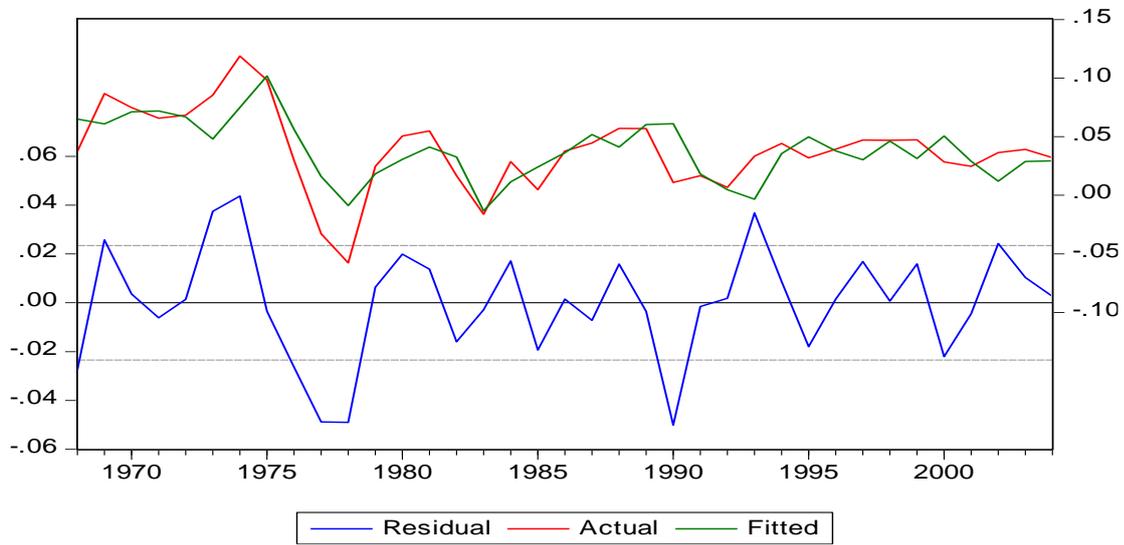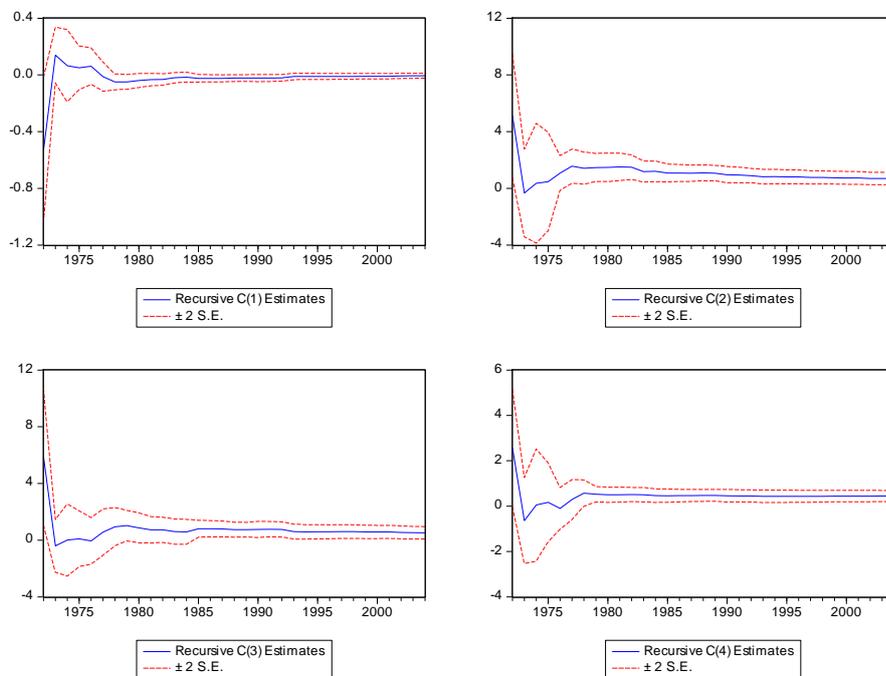
Figure 1

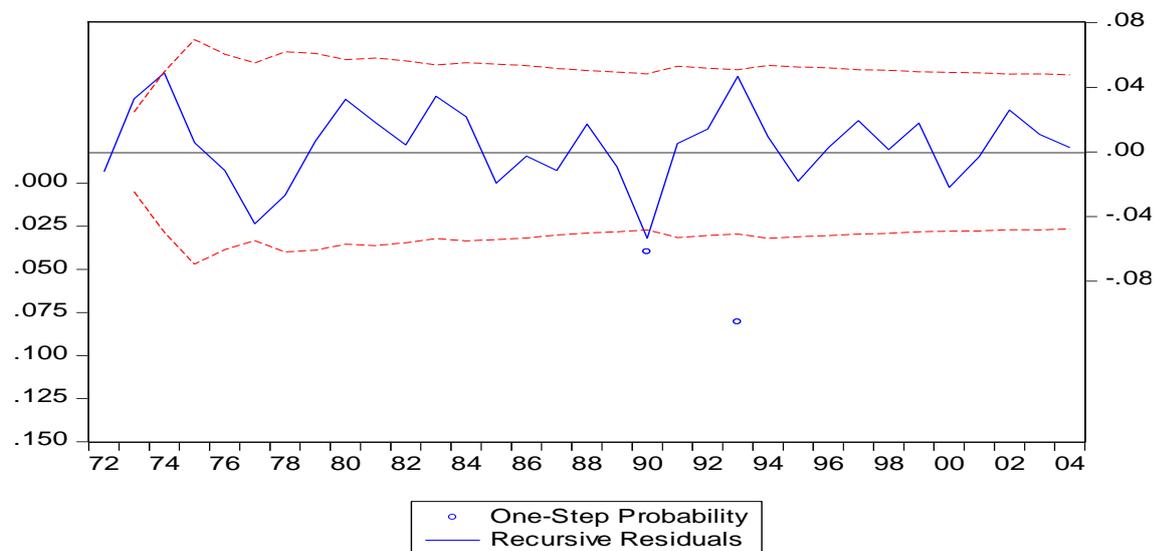Actual-to-predicted Plots (Table 5)

Figure 2

Recursive Coefficient Plots (Table5)

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[4] This lag is consistent with the findings of Wei et al (2012).

Figure 3

One Step Forecasts (Table5)

Recursive estimation was conducted and stable estimated coefficients are recorded from about 1980 onwards (Figure 2). One-step (Figure 3) and N-step forecasts only identified one outlier in 1990, most likely due to the change in the data set used in that year.

Table 6

Dependent Variable: $dlnGDPS_t$

Sample (adjusted): 1968 2004 (37 observations)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$c\lambda$	0.006	0.007	0.992	0.329
$dlnL_t$	0.606	0.158	3.835	0.000
$dlnE_{t-2}$	0.441	0.152	2.905	0.007
$dlnGDPS_{t-1}$	0.309	0.091	3.383	0.002
DUM1974	0.049	0.017	2.854	0.080
DUM1977	-0.055	0.017	-3.221	0.003
DUM1978	-0.064	0.018	-3.597	0.001
DUM1990	-0.049	0.017	-2.908	0.080

R-squared	0.811	Mean dependent var.	0.038
Adjusted R-squared	0.766	S.D. dependent var.	0.034
F-statistic	17.814	Durbin-Watson stat	2.128

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.319	Prob. F(2,27)	0.284
Obs*R-squared	3.293	Prob. Chi-Square(2)	0.193

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However, it is clear in the actual-to-predicted plots (Figure 1) that there are some significant

deviations in the turbulent mid-1970s. So the model was re-estimated and impulse dummies for

1974, 1977, 1978 and 1990 were found to be significant. The results are reported in Table 6.

Inclusion of impulse dummies has a minor effect on the result, raising the significance of all variables

and lowering the sum of exponents after full adjustment to 1.5. This model fits well (Figure 4).
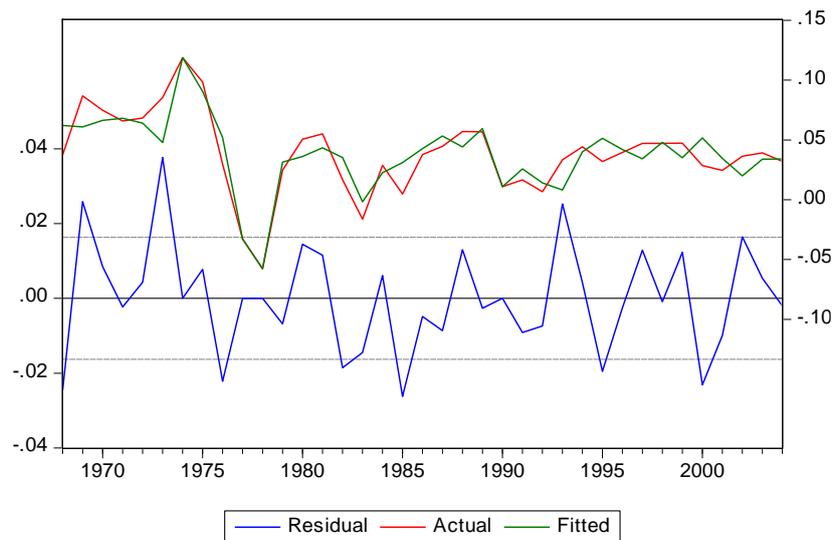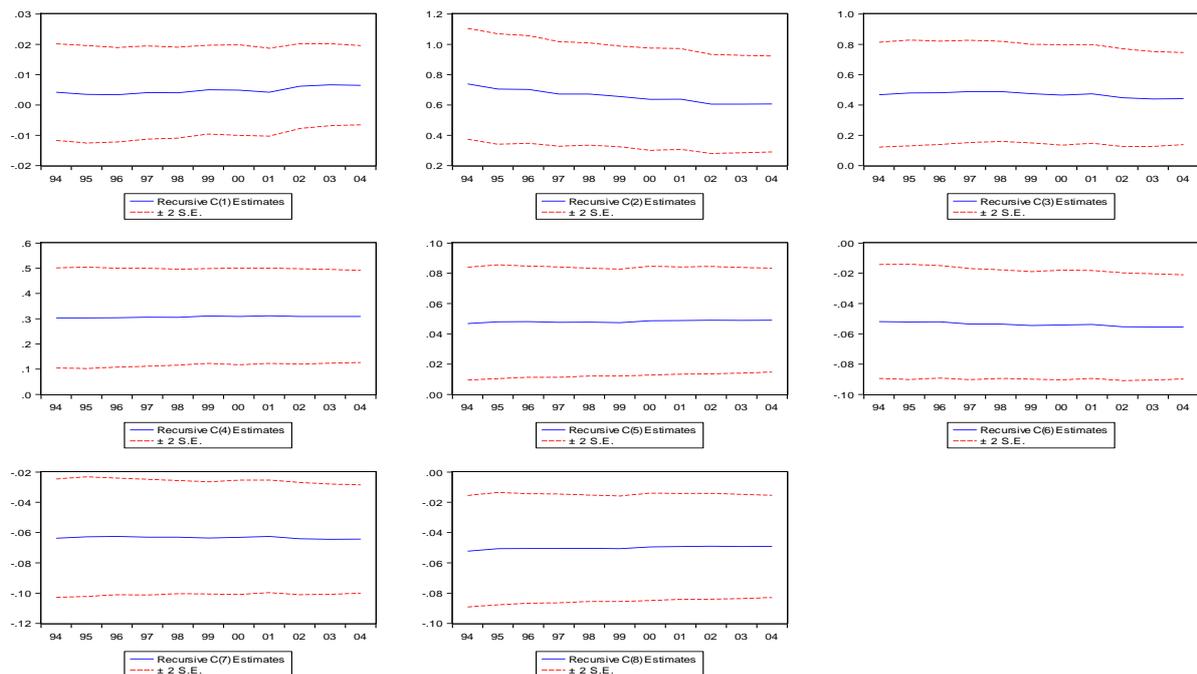
Figure 4

Figure 5
Recursive Coefficient Plots (Table 6)

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Recursive estimation revealed very stable estimated coefficients (Figure 5). Because there is a lagged dependent variable in the model, the Breusch-Godfrey Serial Correlation Test was conducted and there was no evidence that serial correlation was present.

So this preliminary evidence suggests that multi-factor productivity growth, as defined by the ABS and the PC, has not been the driver of Australian economic growth. This is in line with the findings of Diewert and Fox (2008) for the US. So, although much more detailed research is required, it has been quite easy to produce preliminary evidence that increasing returns to scale are important in determining Australia's economic growth. In any growing economy that has an imperfectly competitive industrial structure, we should expect to observe increasing returns to scale.

5. Conclusions

There has been much discussion of Australia's supposed 'productivity crisis' based upon estimates of multi-factor productivity growth. It has been shown here that it is easy to establish that such estimates are invalid and preliminary evidence suggests that economies of scale, rather than multi-factor productivity growth, are likely to have been driving economic growth.

In recent years, what we seemed to have observed is not a productivity crisis but, rather, relatively high rates of labour productivity growth made possible by well-managed investments in capital goods and a workforce which has been able to up-skill to take advantage of the capabilities of new capital goods, particularly computers of all kinds that have enabled massive increases in network connections and consequent scale advantages. This has resulted in increases in both wages and profits with a secular shift in the share of GDP towards the latter. Recently, this has all occurred in the face of a very high Australian dollar. And, of course, it is the pressure imposed by the high currency that has led to pleas by some industrial groups for government to enact policies that lower wage costs, purportedly to raise productivity. Yielding to such pressure would be a serious mistake

since it would encourage increases in labour intensity in production and provide a disincentive to innovate through capital investment strategies (Dodgson et.al. (2012)).

From a policy perspective, an economy enjoying economies of scale must be treated differently to one where it is presumed that disembodied Hicksian technical progress is the dominant driver of growth. Economics of scale are not just about growth in quantities, they also arise because on increases in quality. Economic growth is the outcome of a developmental process involving parallel increases in organisation and complexity (Hausmann and Hidalgo (2011)). As scale increases, the network structure of the economy expands and the range of goods and services increases. This increase in diversity leads to increases in value-added in the whole economy. This is particularly true in the service sector where variety has increased massively as the size of the sector has grown. Much of this 'qualitative' productivity growth is not adequately measured and, thus, not fully reflected in MFP growth calculations. This is acknowledged in Productivity Commission (2014), p.38, even in manufacturing. In relation to small scale bakeries it is noted that "the higher quality…may not be fully reflected in the measures of real value added growth for the subsector, given the challenges in measuring quality."

What has been offered here is preliminary econometric evidence. So it is essential that much more careful research is undertaken to understand fully the role of both static and dynamic economies of scale and scope in determining Australian economic growth before decisions are made concerning a new policy designed to enhance productivity growth. Thompson and Webster (2013) point clearly in the direction that research should go: the interconnected processes of innovation and entrepreneurship are the ultimate drivers of productivity growth and, therefore, should be at the core, not the periphery, of econometric studies (Banerjee (2012), Foster (2014)). In the meantime, it would be useful if the Productivity Commission stopped publishing its highly misleading estimates of marginal factor productivity growth.

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Data Sources

GDP

The annual gross domestic product series from 1965 to 1990 is taken from Snooks (1994) Table 7.9

p. 181. The remaining 14 years of data are obtained from the ABS national accounts given in current

prices but converted to constant prices by chaining the relevant ABS deflator with the Snooks (1994)

deflator.

Capital Stock

The annual capital stock index used is taken from DCITA (2005), Table 1, p.15.

Labour

The annual total labour hours index used is taken from DCITA (2005), Table 1, p.15.

Energy

The BP Statistical Review of World Energy contains annual data on the production and consumption

of coal, oil, gas, hydroelectricity and other renewables in Australia since 1965, courtesy of the

International Energy Agency.

Multi-Factor Productivity Growth

ABS Multi-Factor Productivity and the Diewert-Lawrence Total Factor Productivity Estimates are

drawn from DCITA (2005), Table 1, p.15