CAPITAL STOCK, LABOUR PRODUCTIVITY AND PER CAPITA OUTPUT IN THE STATES OF AUSTRALIA, 1984/5-2003/4[1]

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ABSTRACT: This paper uses newly available estimates of the capital stock to explore the role of capital in the economic performance of the various states of Australia, in terms of gross state product per capita and labour productivity. A variant of standard growth decomposition methodology is used, allowing distinction to be made between the impact of changes in the output-to-capital ratio and that of capital deepening (an increase in the capital-to-labour ratio). Both of these factors are found to have played important roles in determining output and labour productivity growth. Analysis is also made of estimates of the capital stock disaggregated by type. The results suggest that interstate variations in the private-sector components of the capital stock, particularly those categorised as 'machinery and equipment' and 'non dwelling construction', have been more influential on relative performances with respect to aggregate output growth than those associated with the public-sector components.

1. INTRODUCTION

In a recent paper, Mikhailitchenko, et al. (2005) made available a new set of estimates of the aggregate capital stock, as well as its main components, for all Australian states for the period 1984/5-2003/4. The purpose of the current paper is to analyse these estimates, with a view to gaining a better understanding of the roles played by the capital stock in helping to determine differences in the economic growth performance of these states.[2]

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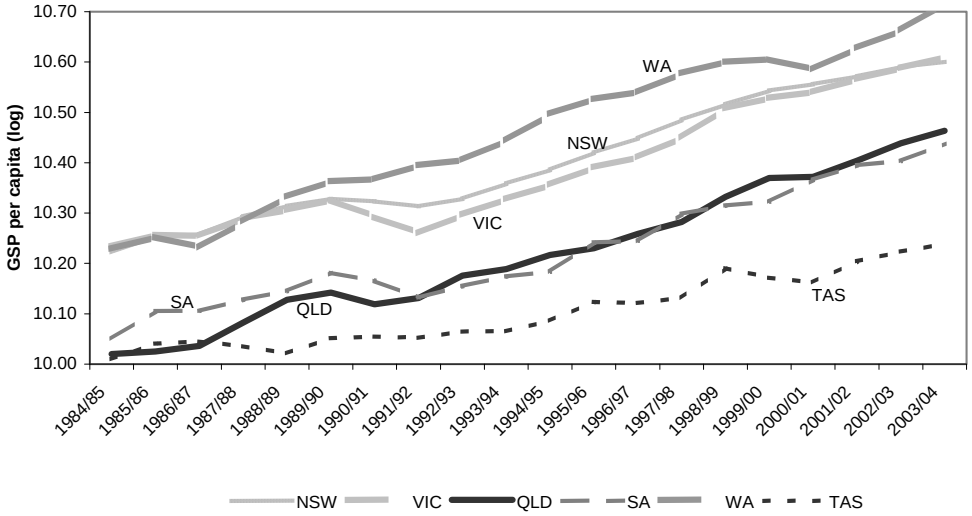
[2] The analysis in this paper will exclude the territories (Northern Territory and Australian Capital Territory) because of concern over the quality of the data at this level of spatial disaggregation in a number of industrial sectors. The data required are typically derived

To clarify the issues involved, consider Figure 1, which shows movements in real gross state product (GSP) per capita over the period 1984/5-2003/4, with the data being presented in natural logarithms to better illustrate growth trends. (The sources of the data, and the methods used to derive the real GSP series as well as other key data series, are described in Appendix A.) For convenience, the following (fairly standard) abbreviations will be employed throughout this paper: NSW for New South Wales, VIC for Victoria, QLD for Queensland, SA for South Australia, WA for Western Australia, TAS for Tasmania, and AUST for Australia.



Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Figure 1. Q/P: GSP Per Capita (in Natural Logs)

Consistent with the findings of previous studies -- such as Harris and Harris (1992), Cashin (1995), Neri (1998), and Nguyen, et al. (2003, 2006) -- the growth paths can be divided into two groups. The upper group (comprising NSW, VIC and WA) records the highest per-capita GSP levels, while the lower group (comprising QLD, SA and TAS) records the lowest levels. It can be observed that, over much of the period being analysed, WA surged ahead of the other states in the upper group. By comparison, TAS failed to keep up with the other states in the lower group and, in the latter part of the period, could be seen as forming a group of its own. There appears to be little or no evidence of the

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from statistical returns received by the Australian Bureau of Statistics from a sample of firms in any given industry. Where the size of the industry is small in a given geographic location, sampling based on a different set of firms for one observation compared with the next may provide an unreliable indication of the true situation, e.g. in terms of output or productivity change.

historically and internationally prevalent tendency for (sub-national) regional per-capita GSP levels to converge, and indeed -- in the light of the experiences of WA and TAS -- some strong indication of a divergence pattern.

These differences in the states' growth experiences deserve further analysis. Previous studies, such as Nguyen, et al. (2003, 2006), have found that a large part of these interstate variations in per-capita output can be explained in terms of variations in labour productivity (LP). This, in turn, raises the question of what causes LP to move differentially. From the definition of LP and a straightforward decomposition of the concept, it can be seen that an increase in LP could arise as a result of either an increase in the output-to-capital ratio, or an increase in the capital-to-labour ratio (K/L), or both. The newly available capital stock data make it possible to explore these interrelationships further.

The remainder of the paper is organised as follows. Section 2 extends the standard growth decomposition framework to cover key determinants of the level and growth rate of per-capita GSP. The determinants considered include output-capital ratio, capital-labour ratio, labour productivity, number of hours worked per employed person, ratio of employed persons to population, and number of hours worked per capita. In Section 3, the extended decomposition framework is applied to historical data to estimate the contributions of these determinants to interstate differences in the levels of GSP per capita and LP, while Section 4 aims to achieve a similar purpose with regard to their growth rates. Section 5 investigates whether the relationships identified in the analysis changed substantially over time, and Section 6 explores possible differences in the roles played by various components of the capital stock (e.g. machinery and equipment, non-dwelling construction, and public-sector capital assets). Finally, Section 7 presents a consolidated summary of the main findings as well as a number of policy implications, and outlines key limitations of the approaches used in the paper, and some directions for future research.

2. THE DECOMPOSITION FRAMEWORK

The standard decomposition methodology -- followed by, for example, the Australian Bureau of Statistics (ABS) (2004) -- can be extended to highlight the role of the capital stock and other key determinants of per-capita GSP, as follows. First, for each jurisdiction j and time period t, output per capita is decomposed by means of an identity:

$$(Q/P)_{jt} \equiv (Q/K)_{jt} \times (K/L)_{jt} \times (L/N)_{jt} \times (N/P)_{jt} \qquad (1)$$

where:

- Q = GSP (or GDP), real gross state (domestic) product;
- P = estimated resident population;
- N = number of employed persons;
- L = total number of hours worked; and
- K = net capital stock (NCS).

(For simplicity, the subscripts j and t are dropped where the context makes it clear which jurisdiction and time period are being referred to.) The ratio Q/P on

the left hand side of equation (1) is real gross state (or domestic) product per head of population, i.e. *output per capita*. The intuitive meanings of the four ratios on the right hand side of equation (1) can be described as follows.

Q/K = *output-to-capital ratio*. A rise in the Q/K ratio indicates a rise in either the rate of *capacity utilisation* of the capital stock (i.e., more units of the capital stock are being utilised), or in *capital productivity* (i.e., each unit of the capital stock that is being utilised is associated, on average, with a greater volume of output), or both;

K/L = *capital-to-labour ratio.* In the current context, this refers to the value of capital stock available on average per hour worked. A rise in this ratio indicates *capital deepening* in that each unit of labour has more capital to work with;

L/N = *hours worked per employed person.* A decline in this ratio would be consistent with increasing "casualisation" of employment, i.e., greater reliance on part-time employees;

N/P = *employment-to-population ratio.* While this concept is similar to the conventional labour force participation rate, its numerator is the number of people who are employed (rather than those who are either employed or looking for work) and its denominator is the total population (rather than just the civilian working-age population).[3]

The combination of the first two terms on the right hand side is commonly referred to as *labour productivity*:

$$(Q/L)_{jt} = (Q/K)_{jt} \times (K/L)_{jt} \qquad (2)$$

The identity in (1) can be linearised by taking natural logarithms:

$$\ln(Q/P)_{jt} = \ln(Q/K)_{jt} + \ln(K/L)_{jt} + \ln(L/N)_{jt} + \ln(N/P)_{jt} \qquad (3)$$

Taking the derivatives of (3) with respect to time gives:

$$gr(Q/P)_{jt} = gr(Q/K)_{jt} + gr(K/L)_{jt} + gr(L/N)_{jt} + gr(N/P)_{jt} \qquad (4)$$

where gr(X) represents the proportional rate of growth of the variable X. Similarly, from (2) we can derive:

$$gr(Q/L)_{jt} = gr(Q/K)_{jt} + gr(K/L)_{jt} \qquad (5)$$

The decomposition in (4) and (5) allows the role of the capital stock to be explicitly considered, thus extending analyses that focus exclusively on LP, such

[3] Since our focus is on the impact of capital stocks on labour productivity and hence output change, rather than the impact of the age structure of the population or the unemployment rate, we have chosen to include a limited number of labour-market factors in the growth decomposition equation.

as Nguyen, et al. (2003) and Crossman, et al. (2006).[4] The terms on the right hand side of (4) can be interpreted both as *growth rates* of the four factors identified, and as their *contributions* to growth in output per capita, as measured by the term on the left hand side.[5] Similarly, equation (5) shows how growth in LP can be decomposed into two terms involving the Q/K and K/L ratios. Indeed, the last two terms on the right hand side of equation (1) can also be combined in the same way to give:

$$(L/P)_{jt} = (L/N)_{jt} \times (N/P)_{jt} \quad (6)$$

and

$$gr(L/P)_{jt} = gr(L/N)_{jt} + gr(N/P)_{jt} \quad (7)$$

which place emphasis on labour-market and demographic issues.

3. DECOMPOSITION OF OUTPUT AND PRODUCTIVITY LEVELS

In this section, the decomposition of output per capita and LP, as expressed in equations (1) and (2), is applied to the data for Australian states during the study period. Figure 2 displays movements in the L/N ratio over time. As can be seen, the number of hours worked per employed person followed a downward trend in every state during this period, reflecting a compositional shift toward part-time employment in each state. The figure also shows that the L/N ratio was considerably lower in TAS than in the other states throughout the period, suggesting that labour-market conditions were far weaker in TAS.

Consistent with that impression, Figure 3 shows that the employment-to-population ratio, N/P, for TAS was also much lower than for the other states, while WA was generally in the opposite relative position. Most states experienced a rising trend in this ratio during the period under examination, with a major exception being the recession years of the early-1990s. The growing trend in N/P may have been associated with a rise in the participation rate on the supply side, as well as an increasing preference by employers for part-time workers on the demand side.

As per equation (6), L/P combines the above two ratios: it gives the number of hours worked per capita, and is illustrated by Figure 4. The interstate patterns are rather similar to those exhibited in Figure 3. Once again, TAS was at a much lower level compared with the other states, while WA was at the top during most of the period being examined. Referring back to equation (1), the foregoing

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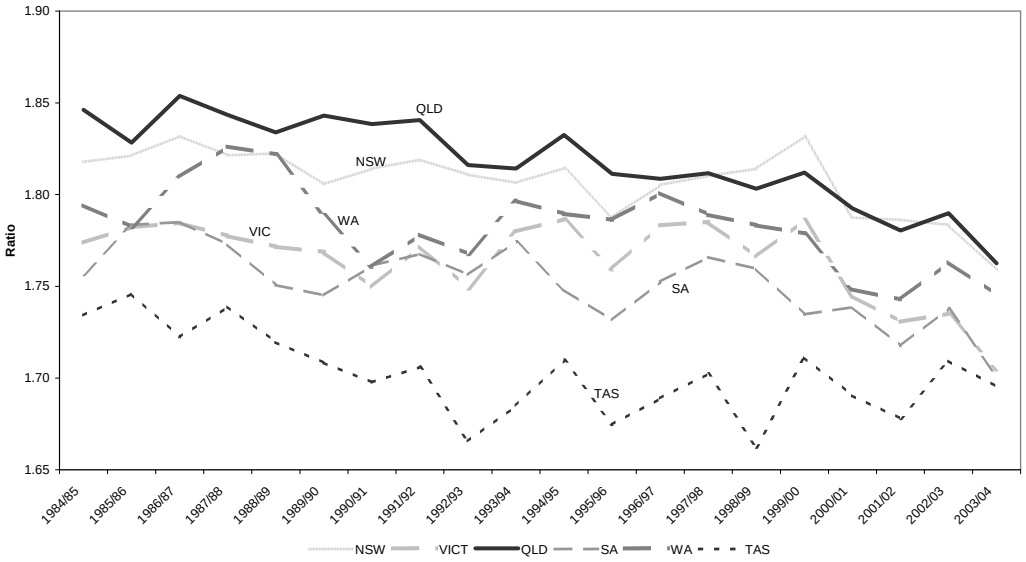
[4] While these equations hold exactly in continuous time, their discrete-time analogues hold only approximately. Nevertheless, the approximations should be very close if the growth rates involved are relatively small, as in the current case.

[5] This is an application of the concept of 'contribution to change' commonly used, for example, by the ABS and state treasuries in their national and state accounts publications -- for example, in analysing contributions by the various expenditure components to overall growth in gross domestic or state product.

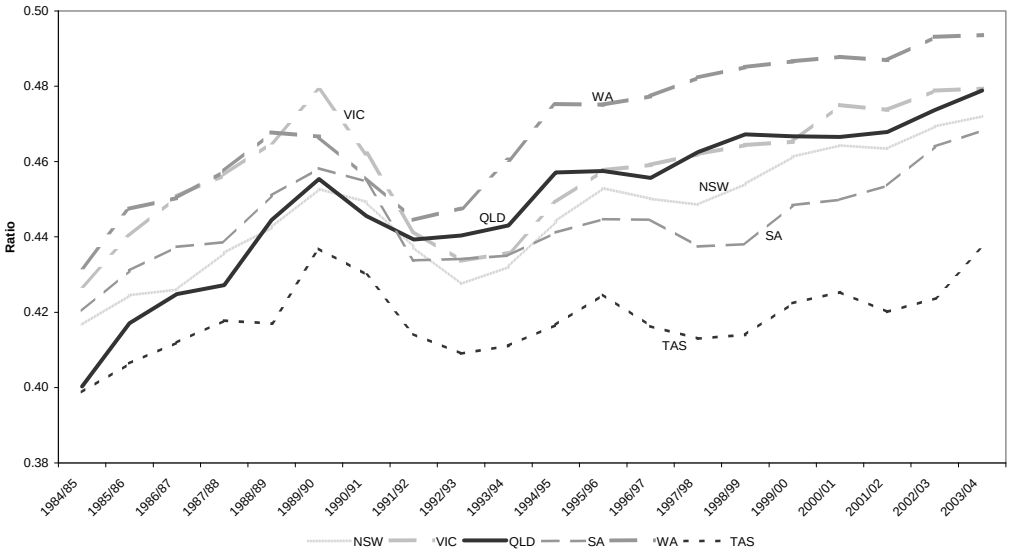
analysis provides a partial explanation for the interstate differences in output per capita (Q/P) levels highlighted in Section 1. High L/P ratios in WA, VIC and NSW helped them to enjoy higher Q/P ratios than states (like TAS and SA) whose L/P ratios were low. The exception to this rule is QLD, whose relatively high L/P ratio failed to translate into a correspondingly high Q/P. The reason for this outcome will become more apparent below.



Source: Authors' calculations based on data obtained from sources listed in Appendix A.

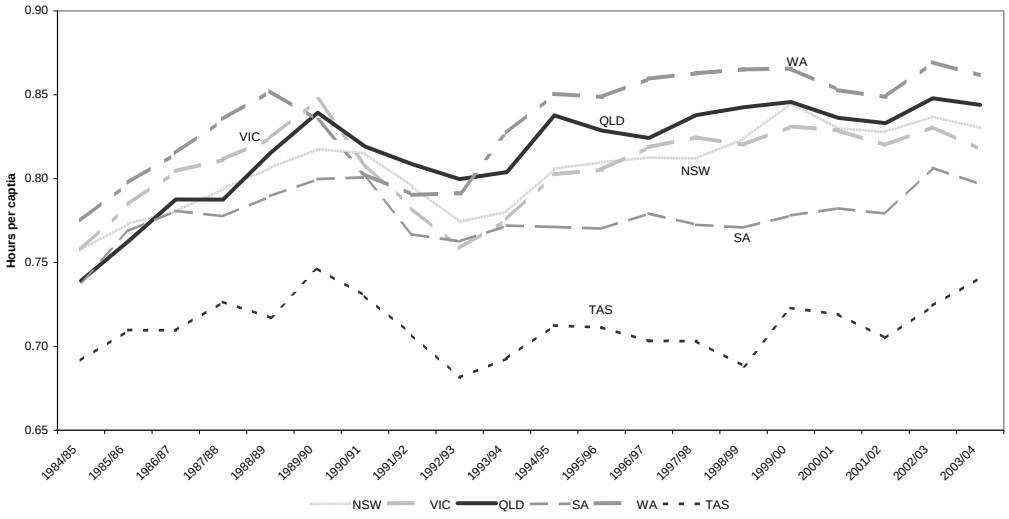
Figure 2. L/N: Number of Hours Worked per Employed Person

From equations (1) and (2) we can also see the potential role of labour productivity (the Q/L ratio) in determining output per capita. Figure 5 portrays movements in this ratio during the study period (again in logs to show the growing trends more effectively). The interstate patterns are very similar to those of Figure 1, confirming the textbook rule of thumb that an economy's performance in terms of output per capita is generally underpinned by its performance on the labour productivity front. In the current context, high Q/L ratios in WA, VIC and NSW contributed to high per-capita output levels in these states, while low Q/L ratios contributed to opposite outcomes in TAS and SA. It is of interest to note that, in QLD's case, the negative effect of the low Q/L ratio being examined here outweighed the positive effect of the high L/P ratio mentioned above, so that the state's per-capita output was relatively low (see Figure 1).



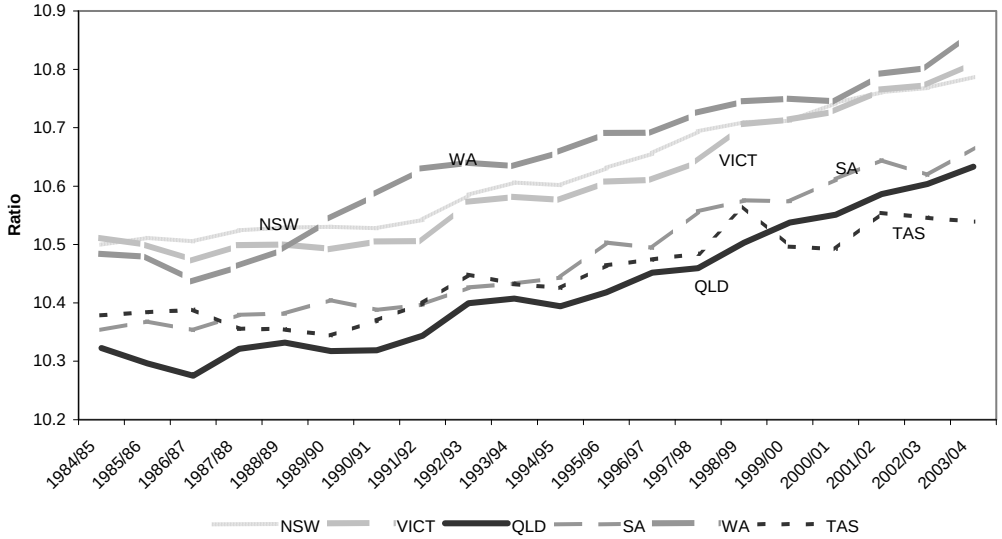
Source: Author's calculations based on data obtained from sources listed in Appendix A.

Figure 3. N/P: Ratio of Employed Persons to Population



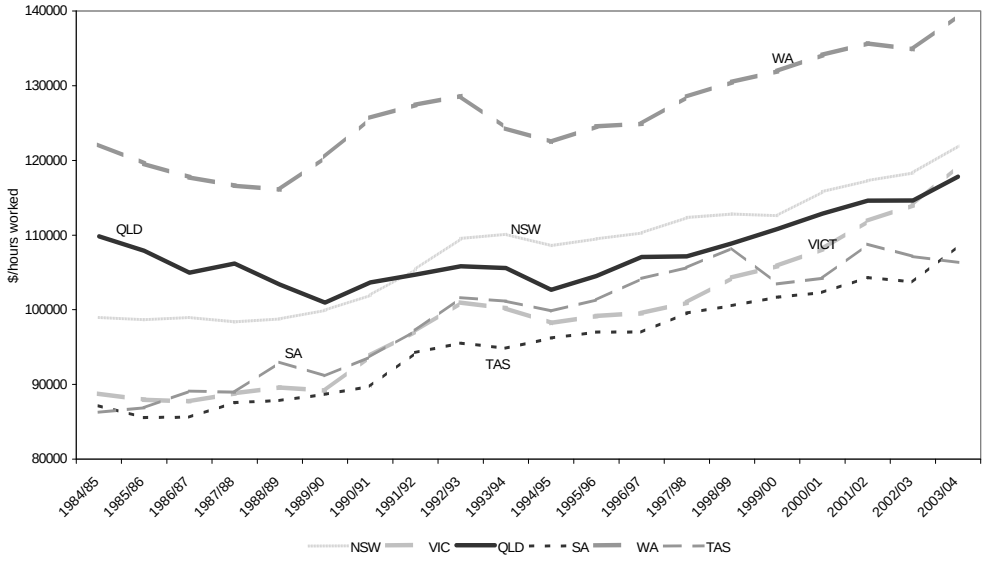
Source: Author's calculations based on data obtained from sources listed in Appendix A.

Figure 4. L/P: Number of Hours Worked Per Capita



Source: Authors' calculations based on data obtained from sources listed in Appendix A

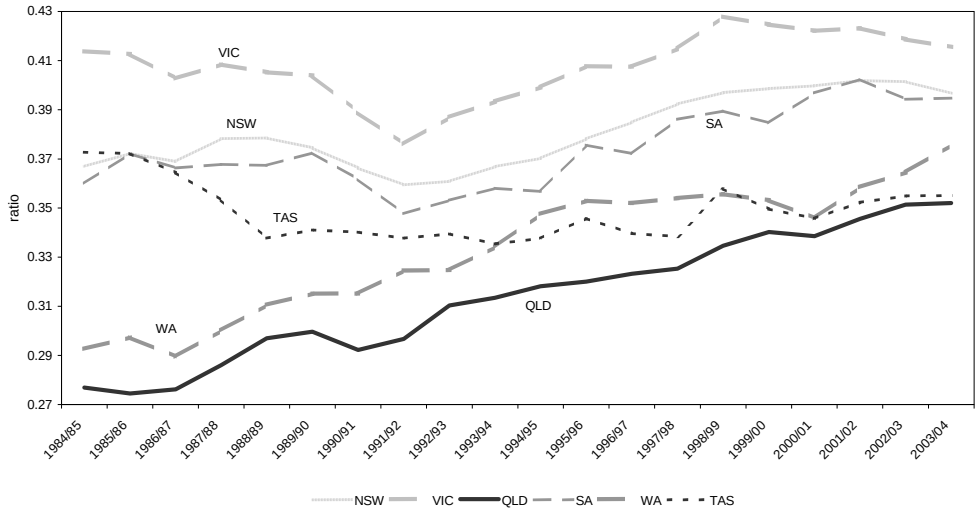
Figure 5. Q/L: GSP Per Hour Worked (in Natural Logs)



Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Figure 6. K/L: Net Capital Stock Per Hour Worked

In view of the critical role played by the Q/L ratio in determining relative per-capita output levels, the main purpose of the present analysis is, as stated in Section 1, to focus on key factors underlying this ratio. The starting point for this part of the investigation is equation (2), which decomposes labour productivity (Q/L) into the output-to-capital (Q/K) and capital-to-labour (K/L) ratios. Figure 6 presents an interstate comparison of the K/L ratios over time. It is evident that, throughout the study period, labour in TAS and SA generally had less capital to work with than in the other states, while labour in WA consistently had far more, and the same was true but to a lesser extent for NSW. By comparison, QLD's K/L ratio started out being higher than that of most other states, but then declined toward the national average during the second half of the 1980s and first half of the 1990s. VIC provided an interesting contrast: having started the period towards the bottom of the pack, it then closed the gaps between itself and the three top states (WA, NSW and QLD). The fact that capital assets available per worker-hour in WA were more plentiful than in other states contributed to the high productivity of WA's labour, just as the low K/L ratios in TAS and SA contributed to the low Q/L ratios in these states.



Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Figure 7. Q/K: Ratio of GSP to Net Capital Stock

As capital was relatively abundant in WA and (to a lesser extent) in QLD, the output-to-capital (Q/K) ratio was generally lower in these states; see Figure 7. Such low Q/K ratios negated to some extent the positive effects of capital abundance. Indeed, in QLD's case, the net effect was to leave the state with one

of the lowest labour productivity levels (see also Figure 5). In both cases, however, there was a general tendency for Q/K to rise toward the national average, reflecting either increasing capacity utilisation or rising capital productivity (or both). By contrast, TAS's Q/K ratio exhibited a slight downward trend. Further, despite having a low K/L ratio (as seen in Figure 6 previously) TAS was among the states with the lowest Q/K ratios. Conversely, although NSW was among the most capital-abundant states (see also Figure 6) it managed to achieve one of the highest Q/K ratios.

Seen together, Figure 7 and Figure 6 show clearly that TAS's relatively low labour productivity was attributable to both a low Q/K ratio and a low K/L ratio. Thus, a key difference between the experiences of TAS on one hand and SA and VIC on the other is that the latter states were able to maintain Q/K at relatively high levels, thus offsetting to some extent the negative effects of their low K/L ratios. In another contrast with TAS, the high labour productivity in NSW was attributable to both a high Q/K ratio and a high K/L ratio. The key difference between WA and QLD is that although the former state had a far higher K/L ratio, it also achieved a higher Q/L ratio.

As seen above, TAS had one of the lowest Q/K ratios, despite the fact that capital was relatively scarce there. Possible reasons for this include: (a) on average each unit of capital in TAS may have been less productive than a corresponding unit of capital in other states, (b) less of the available capital stock capacity may have been used in TAS than elsewhere, and (c) both the above. The fact that labour utilisation indicators (for example, L/P and L/N) were lower in TAS suggests that (b) or (c) may be closer to the real situation. This poses special difficulties for the state in any effort to raise labour productivity. In particular, the usual prescription of capital deepening, i.e. raising the K/L ratio, may not be very effective if there is still ample unused capacity among the existing stock of capital assets.

In summary, labour productivity (Q/L) played a major role in determining output per capita (Q/P). In turn, labour productivity was determined by both the capital-to-labour (K/L) and output-to-capital (Q/K) ratios. In NSW, both of these ratios were high, ensuring a high level of labour productivity. In TAS, by contrast, both ratios were low, resulting in a low level of labour productivity. In WA, a very high K/L ratio was sufficient to outweigh a low Q/K ratio, while QLD's K/L ratio was insufficiently high to achieve a similar outcome for the latter state. In VIC and (to a lesser extent) SA, high Q/K ratios counteracted against the negative effects of low K/L ratios.

4. DECOMPOSITION OF GROWTH IN OUTPUT AND PRODUCTIVITY

While Figures 1-7 and equations (1)-(2) help us to gain a better understanding of the interstate differences in the levels of output per capita and labour productivity, equations (4), (5) and (7), and Table 1 facilitate analysis of the corresponding variations in their *rates of growth*. The table shows in summary form the contributions of the determinants identified above to per-

capita output growth during the study period[6] for each of the states and for Australia as a whole. (Similar tables, available from the authors upon request, record the disaggregated year-by-year contributions for each jurisdiction.)

Table 1. Contributions to Per Capita Output Growth over Full Period, 1984/5 to 2003/4 (per year)

	Q/K	K/L	Q/L	L/N	N/P	L/P	Q/P
	Contributions to Per Capita Output Growth *(Percentage Points)*						
NSW	0.42	1.11	1.53	-0.17	0.67	0.50	2.02
VIC	0.04	1.59	1.62	-0.20	0.63	0.43	2.02
QLD	1.28	0.39	1.67	-0.24	0.96	0.72	2.38
SA	0.51	1.18	1.68	-0.16	0.58	0.41	2.09
WA	1.34	0.72	2.07	-0.14	0.72	0.58	2.63
TAS	-0.23	1.13	0.90	-0.11	0.50	0.39	1.23
AUST	0.51	1.09	1.60	-0.18	0.70	0.52	2.11
	Shares of Total Contribution to Per Capita Output Growth *(Percent of Total)*						
NSW	20.8	55.1	75.7	-8.4	33.1	24.5	100.0
VIC	2.0	78.6	80.2	-10.0	31.2	21.1	100.0
QLD	54.1	16.4	70.4	-10.1	40.4	30.3	100.0
SA	24.5	56.4	80.7	-7.8	27.9	19.9	100.0
WA	51.1	27.5	78.6	-5.3	27.3	22.0	100.0
TAS	-18.8	91.9	73.1	-8.8	40.7	31.9	100.0
AUST	24.1	51.6	75.7	-8.5	33.2	24.6	100.0

Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Growth in *per capita output* (Q/P) is given in the rightmost column of Table 1, with WA (at 2.63 percent) and to a lesser extent QLD (2.38 percent) standing out as performing above the national average (2.11 percent). The performance of TAS (1.23 percent) was substantially below that of the other jurisdictions. All of these are consistent with the trends displayed in Figure 1 above.

[6] The average growth (contribution) rate of each variable or factor over the full period (i.e. 1984/5 to 2003/4) is calculated as the simple arithmetic mean of the corresponding annual growth rates for each jurisdiction. We have also calculated the average growth rate as the compound growth rate implied by the values at the two end-dates, namely 1984/5 and 2003/4. The resultant differences are quite minor. The simple average approach was adopted in this case to preserve consistency with the analysis for shorter sub-divisions of the study period, where the compound growth rate approach is more sensitive to short-term, cyclical variations in the end-year values.

Rates of growth in the *number of hours worked per employee* (L/N) and the *employment-to-population ratio* (N/P) are also reported in Table 1. They reflect changes in the labour market, industrial structure, and demographic factors, and while these are not the primary focus of the paper, some trends and patterns deserve mention. For example, growth in L/N was negative in all jurisdictions. This may have occurred because greater prosperity allowed an increase in leisure and, correspondingly, a fall in the average number of hours worked. It might also reflect a trend toward part-time rather than full-time job opportunities in many industries and geographic locations. In some instances, the latter trend could mask significant pockets of under-employment, where part-time jobs were taken up by workers who would have preferred to be employed full-time if that option had been available to them. In other instances, it could reflect a buoyant local job market, with employers unable to attract sufficient full-time employees and forced to offer part-time opportunities to entice additional labour into the workforce.

In view of these conflicting possible explanations, generalisations across jurisdictions would be unreliable. Instead, local conditions warrant closer examination. For example, the sharper decline in QLD (-0.24 percent compared with -0.18 percent nationally) may have been related to the industrial structure of employment in the state, which has experienced high growth in industries, such as tourism, in which the proportion of part-time employment is typically higher than in other industries. By contrast, the slower decline in TAS (-0.11 percent) might have been due to the fact that the number of hours worked per employee in this state was already at a low level at the beginning of the period (see Figure 2).

Growth in the *employment-to-population ratio* (N/P) was a significant factor determining per-capita output growth, accounting on average for about 0.70 percentage points (or 33.2 percent) of the total annual growth in this variable at the national level. Changes in this ratio reflect a number of factors – for example, the age structure of the population, opportunities for part-time work for youth, opportunities for and attitudes towards female workforce participation, and aggregate demand conditions. In absolute terms, this factor appears to have made above-average contributions to per-capita output growth in QLD (0.96 percentage points) and to a lesser extent WA (0.72). By contrast, TAS (0.50) and SA (0.58) stood out as under-average performers. These comparisons are consistent with the findings of other researchers -- that both QLD and WA experienced rapid growth in employment (especially part-time employment), an increase in female workforce participation and significant in-migration of working-age residents, while TAS and SA recorded slower growth in employment and more advanced ageing of the population; see, for example, Jackson (2004).

Combining growth in L/N and N/P yields growth in L/P, shown in the next-to-last column of Table 1. Interstate variations in the growth rate of this ratio followed a similar pattern to that of growth in N/P: QLD (at 0.72 percentage points) and WA again stood out as above-average performers, while TAS (0.39) and SA were again below average. By and large, the *employment-to-population* ratio appears to have driven the *labour-to-population* ratio, with the number of

hours worked per employee (*labour-to-employment* ratio) playing a smaller role, mainly in moderating interstate variations, and in slightly weakening the contributions from each state's labour force to per-capita output growth.

Turning now to the contributions of the capital stock, we note that growth in the *output-to-capital* (Q/K) and *capital-to-labour* (K/L) ratios are recorded in, respectively, the first and second data columns of Table 1. As discussed above, the sum of these two growth rates comprises growth in *labour productivity* (Q/L), recorded in the third column. For Australia as a whole, growth in labour productivity appears to have contributed on average about 1.60 percentage points to annual growth in per-capita output, representing about 75.7 percent of the total contributions. For the various states, this share ranged from a low of around 70 percent for QLD to a high of around 80 percent for SA and VIC. A key contribution of the present analysis is the additional insight it offers into the sources of growth in labour productivity, and the interstate differences in their relative importance.

In particular, the second column of Table 1 shows the contributions of *capital deepening*, i.e., growth in the capital-to-labour (K/L) ratio. For Australia as a whole, this contributed on average 1.09 percentage points to overall per-capita output growth each year. This represents more than half (51.6 percent) of total contributions to such growth, and about two-thirds of the contributions from labour productivity growth. The corresponding figures in Table 1 for the states indicate that capital deepening made a far-below-average contribution to per-capita output growth in QLD (0.39 percentage points) and, to a lesser extent, in WA (0.72). As seen in Figure 6, this merely reflects the fact that the (K/L) ratios in these two states started from much higher bases than in the others. Similarly, the fact that capital deepening contributed more to growth in VIC (1.59 percentage points) is consistent with this state's having started from a much lower base in terms of the K/L ratio.

The first column of Table 1 presents rates of growth in the *output-to-capital-stock* ratio (Q/K). For Australia as a whole, this growth contributed on average 0.51 percentage points to annual per-capita output growth, which is 24.1 percent of all contributions or about one-third of the contribution made by labour productivity growth. In absolute terms, the contribution in WA (1.34 percentage points) and QLD (1.28) were far above the national average, contrasting with a negative contribution in TAS (-0.23) and a far-below-average contribution in VIC (0.04). These growth rates are in accordance with the trends displayed in Figure 7: the Q/K ratio rose steeply in WA and QLD, fell in TAS and showed no obvious secular trend in VIC.

In taking stock, it is clear that the lion's share of annual growth in output per capita in Australia as well as in each state was contributed by the growth in labour productivity (Q/L), with this share ranging from around 70 percent for QLD to 76 percent for Australia as a whole and 81 percent for SA. In absolute terms, the contribution was of the order of 1.6 percentage points, but was as high as 2.1 percentage points for WA and as low as 0.9 points for TAS.

The differences between the states were far bigger with respect to the *sources* of growth in labour productivity. For Australia as a whole, as well as in NSW

and SA, about two-thirds of this growth could be attributed to capital deepening, with the remainder being attributable to rises in the output-to-capital ratio. In VIC and TAS, by contrast, capital deepening accounted for nearly all (VIC) or more than all (TAS) of this growth. Only in WA and QLD did the decomposition accord more weight to growth in the Q/K ratio.

Intuitively, both WA and QLD benefited during the study period from high rates of growth in both the labour-to-population (L/P) ratio and output-to-capital (Q/K) ratio. The latter might have stemmed from the large amounts of capital assets that these states had accumulated previously, relative to the size of their employed labour force. Perhaps because of such capital abundance, both states then engaged in less capital deepening than the other states. Compared to WA, in QLD the K/L ratio fell further and recovered more slowly, thus contributing less to overall economic growth.

In a similar vein, the poor growth performance of TAS can be accounted for by below-average growth in the labour-to-population (L/P) ratio and negative growth in the output-to-capital (Q/K) ratio. A possible development that could explain both of these is that aggregate demand may have been weak, resulting in low rates of capacity utilisation for both the labour force and the capital stock.

The above findings, especially those relating to the Q/K and K/L ratios, need to be treated with some caution, due to the fact that estimates of the capital stock are typically subject to considerable uncertainty. In particular, the perpetual inventory method, which was adopted by Mikhailitchenko, et al. (2005) to derive the capital stock data series being used here, tends to result in estimates that are less reliable in the early part of the series compared with those in the latter part, with implications for any growth rates calculated for the intervening period. This concern is addressed to some extent in the next section, where the study period is divided into two sub-periods, with results for the latter sub-period receiving greater emphasis.

5. SUB-DIVISION OF THE STUDY PERIOD

Examination of Figures 6 and 7 suggests that the comparative experiences of the states have not been uniform over the entire time period under analysis and that further insights might be obtained by exploring the changes over time in the relative importance of the various factors identified above. However, it is probably not very useful to analyse in depth the year-to-year changes, in view of the inherent volatility in data of such frequency, especially capital stock data that reflect the lumpiness of many forms of capital investment. As a compromise solution, the period under examination is disaggregated into two sub-periods, namely 1984/5 to 1993/4, and 1994/5 to 2003/4.[7]

Replicating the calculations for Table 1 yields the results reported in Tables 2 and 3. They indicate that, in keeping with the results for the entire study period, growth in labour productivity (Q/L) accounted for most of the annual growth in

[7] The average growth (contribution) rate of each variable or factor during each sub-period (e.g. 1984/5 to 1993/4) is again calculated as the simple arithmetic mean of the corresponding annual growth rates for each jurisdiction.

output per capita during each of the two sub-periods. This result applied to Australia as a whole as well as most of the states, and appears to be quite robust. The main difference between the two sub-periods in this respect is that, during the latter sub-period and in most jurisdictions, growth in Q/L became even more important, compared with growth in L/P, in determining Q/P growth (see the lower panels of Tables 2 and 3).

Table 2. Contributions to Per Capita Output Growth over First Sub-Period, 1984/5 to 1993/4 (per year)

	Q/K	K/L	Q/L	L/N	N/P	L/P	Q/P
	Contributions to Per Capita Output Growth *(Percentage Points)*						
NSW	0.01	1.20	1.20	-0.07	0.42	0.35	1.54
VIC	-0.54	1.38	0.82	0.04	0.26	0.31	1.08
QLD	1.41	-0.42	0.98	-0.19	1.15	0.96	1.91
SA	-0.04	0.96	0.89	0.12	0.40	0.52	1.41
WA	1.50	0.23	1.72	0.02	0.73	0.76	2.45
TAS	-1.15	1.81	0.63	-0.31	0.36	0.05	0.63
AUST	0.18	0.87	1.05	-0.04	0.53	0.49	1.53
	Shares of Total Contribution to Per Capita Output Growth *(Percent of Total)*						
NSW	0.7	78.2	78.0	-4.4	27.1	22.5	100.0
VIC	-49.7	127.2	75.6	3.9	24.1	28.2	100.0
QLD	73.6	-21.8	51.3	-10.0	60.3	50.2	100.0
SA	-2.8	68.1	63.3	8.4	28.5	36.7	100.0
WA	61.3	9.3	70.5	0.9	29.9	31.1	100.0
TAS	-184.1	289.0	100.1	-50.1	58.2	8.2	100.0
AUST	12.0	57.1	68.6	-2.7	35.0	32.3	100.0

Source: Authors' calculations based on data obtained from sources in Appendix A.

Further, to the extent that the capital stock data used are reliable, the results suggest that in most jurisdictions and in both sub-periods, rises in the K/L ratio were more important as a source of labour productivity growth than were rises in the Q/K ratio.[8] Focusing on the second sub-period (Table 3) for which capital stock data are likely to be more reliable, it can be seen that growth in the K/L

[8] The jurisdictions which were exceptions to this rule were WA, where capital deepening played only a minor role in the first sub-period, and QLD, where the K/L ratio actually declined during the same time frame; see also Figure 6. Because of the nature of the capital stock estimates involved, it is considered prudent not to place too much emphasis on these anomalies.

ratio accounted for more than one-half of the growth in labour productivity in Australia as a whole as well as in three of the larger states, namely NSW, VIC and SA. However, in QLD, WA and TAS, contributions to growth made by rises in the Q/K ratio were slightly larger than those made by rises in the K/L ratio.

In terms of comparative performances, during the first sub-period, WA and QLD recorded rates of growth in output per capita (Q/P) that were substantially higher than the national average, while the corresponding figure for TAS and VIC were substantially below this average (see the rightmost column of Table 2). In the second sub-period, however, the five larger states experienced similar rates of Q/P growth, with only TAS recording a distinctly below-average rate (see Table 3). As for growth in labour productivity (Q/L), WA and NSW were clearly above average during the first sub-period while TAS and VIC were clearly below. In the second sub-period, four of the larger states had very similar growth rates, with only NSW recording a slightly lower rate, and TAS a much lower rate.

Table 3. Contributions to Per Capita Output Growth over Second Sub-Period, 1994/5 to 2003/4 (per year)

	Q/K	K/L	Q/L	L/N	N/P	L/P	Q/P
	Contributions to Per Capita Output Growth *(Percentage Points)*						
NSW	0.79	1.03	1.83	-0.26	0.89	0.63	2.46
VIC	0.56	1.78	2.34	-0.42	0.96	0.53	2.87
QLD	1.17	1.11	2.30	-0.29	0.79	0.50	2.79
SA	1.01	1.37	2.39	-0.41	0.74	0.32	2.69
WA	1.20	1.16	2.37	-0.29	0.70	0.41	2.79
TAS	0.59	0.53	1.15	0.07	0.63	0.70	1.78
AUST	0.80	1.29	2.10	-0.31	0.85	0.54	2.64
	Shares of Total Contribution to Per Capita Output Growth *(Percent of Total)*						
NSW	32.2	42.1	74.5	-10.6	36.4	25.7	100.0
VIC	19.5	62.0	81.7	-14.7	33.6	18.6	100.0
QLD	42.0	39.9	82.3	-10.2	28.1	18.0	100.0
SA	37.4	50.8	88.9	-15.4	27.6	11.9	100.0
WA	43.0	41.8	85.1	-10.3	25.2	14.8	100.0
TAS	33.4	29.7	64.6	4.2	35.1	39.3	100.0
AUST	30.4	48.8	79.4	-11.6	32.3	20.6	100.0

Source: Authors' calculations based on data obtained from sources in Appendix A.

With regard to contributions by the *capital stock* to labour productivity growth, we will now focus on the second sub-period, due to greater confidence in the relevant capital stock data. From Table 3, it can be seen that VIC led the states in capital deepening (growth in K/L) while TAS lagged far behind. The positive effects of the strong K/L growth in VIC were offset to some extent by weak growth in the Q/K ratio. For TAS, a similarly low rate of Q/K growth reinforced the negative effects of the weak K/L growth, resulting in the low rate of Q/L growth mentioned above.

In summary, in the second sub-period, interstate variations in per-capita output and labour productivity growth became less pronounced than in the first sub-period, while labour productivity growth became even more important than before as a determinant of per-capita output growth. Of the two contributors to growth in labour productivity that have been considered, namely capital deepening and rises in the Q/K ratios, both have been found to exert strong influences, with the relative weights being not too dissimilar in most cases.

6. THE ROLE OF DIFFERENT TYPES OF CAPITAL STOCK

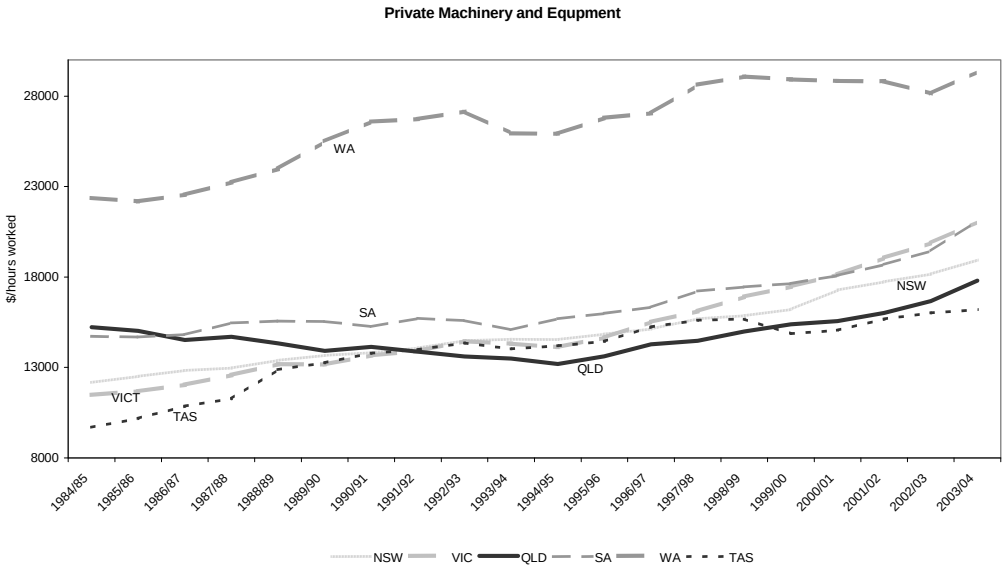
The state capital stock estimates compiled by Mikhailitchenko, et al (2005) refer not only to the aggregate capital stock in each state but also to six sub-categories of this aggregate stock, including:

- private dwellings (DW),
- private non-dwelling construction (NDC),
- private machinery and equipment (ME),
- private livestock,
- private intangible fixed assets, and
- total public assets of all types (PUB).

Of these, the fourth and fifth subcategories represented very small shares of the aggregate stock during most of the study period. Therefore, we focus on the remaining four subcategories in the following analysis.

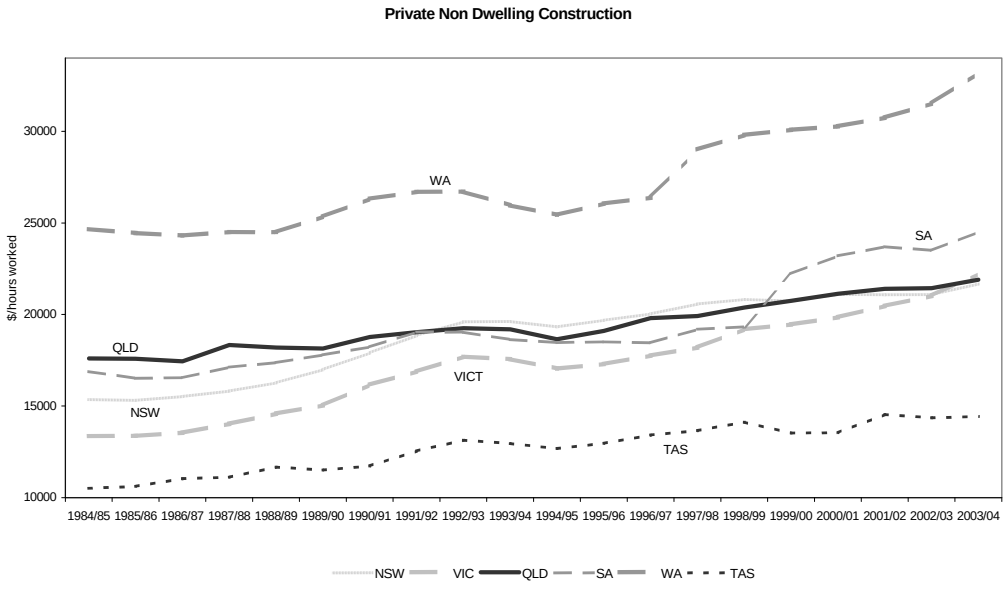
In previous sections of the paper, it has been established that the capital-to-labour (K/L) ratio is a major determinant of labour productivity (Q/L). It is of interest now to investigate whether the composition of K plays an important role in such determination. To this end, Figures 8-11 display comparative movements in four types of K/L ratios: in each figure, K is measured as one of the main subcategories of the capital stock as listed above, and L is measured as the total number of hours worked. Thus, as we move from one figure to the next, the denominator remains the same, while the numerator varies according to the type of capital assets being analysed.

It was observed previously that, in aggregate, the K/L ratio was much higher in WA, and much lower in TAS, than in the other states (see Figure 6) and that these differences contributed to the high Q/L ratio in WA and low Q/L ratio in TAS (Figure 5). Figures 8-11 together show that these aggregative differences were made up from even more exaggerated differences in some components of the capital stock, which were then offset by differences in the opposite direction in another component.



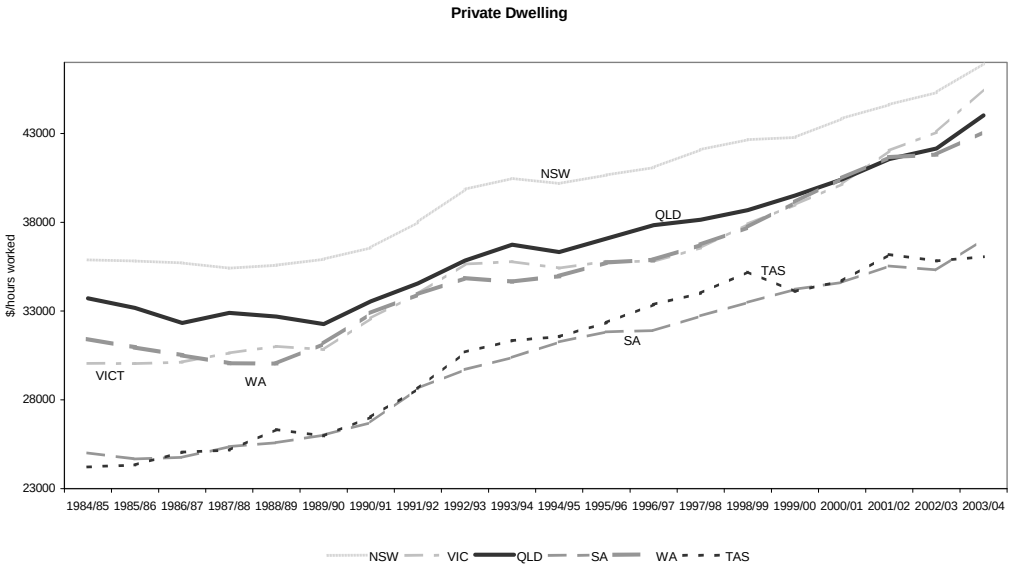
Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Figure 8. K/L: Private Machinery and Equipment Capital per Hour Worked



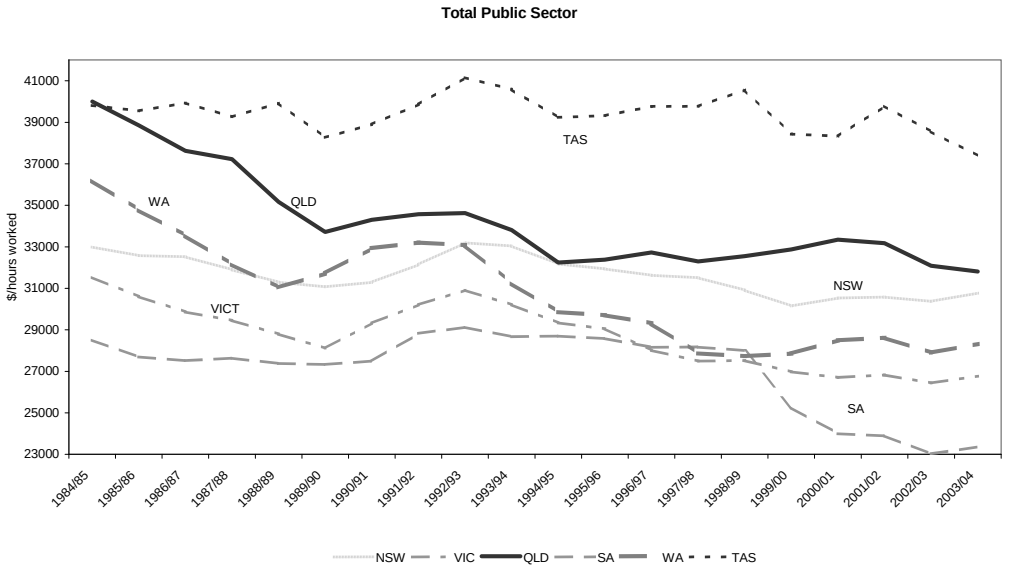
Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Figure 9. K/L: Private Non Dwelling Construction Capital per Hour Worked



Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Figure 10. K/L: Private Dwellings Capital per Hour Worked



Source: Authors' calculations based on data obtained from sources listed in Appendix A.

Figure 11. K/L: Public Sector Capital per Hour Worked

For example, from Figures 8 and 9 it can be seen that the differences between WA and TAS were very large indeed with respect to the amounts of ME (machinery and equipment) and NDC (non-dwelling construction) capital available per worker-hour. It is highly plausible that these differences contributed substantially to the gap in labour productivity between these two states.[9]

By contrast, the amount of PUB (public-sector) capital available per worker-hour was actually higher in TAS than in any other state including WA throughout the period (see Figure 11). While this would have worked to reduce the gap in *aggregate* K/L between WA and TAS, its impact on aggregate labour productivity may have been less certain. In particular, if the high levels of public investment expenditure in this state had been less of the type conducive to facilitating and stimulating private-sector activity and more of the type designed to absorb spare capacity and unemployed labour resources, then the net effect would have been to raise the K/L ratio but possibly to reduce the Q/K ratio. It is also worth noting that while the ratio of PUB capital to labour tended to fall during the study period in most states, the fall was slightest in TAS and quite steep in WA and QLD.[10]

7. CONCLUSION

This paper has made use of recently available estimates of state capital stocks to explore the roles played by these stocks in influencing differential economic performances by the states of Australia, in terms of both the *level* and *growth rate* of per-capita gross state product. It is recognised that raising GSP per capita is typically not the only goal pursued by state governments. A non-exhaustive list of other usual goals includes equitable income distribution, social harmony, improving the quality of life, and preservation of the environment. At times, some of these might even be in conflict with the GSP-maximising goal. Nevertheless, it remains true that per-capita GSP is widely seen as an important indicator of economic performance in most contexts, and the role of capital stocks in generating differential GSP outcomes is, accordingly, of significant interest to both policy makers and academic researchers.

Relatively detailed summaries of some of our findings have been provided at the end of Sections 4, 5 and 6 above. As each of these sections deals with a different aspect of the overall question, it is useful at this stage to draw these

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[9] In part, the high level of NDC capital in WA could be a result of the private sector taking a greater role in this state for the provision of economic infrastructure (such as rails, ports and urban centre development) than in other states, especially in mining areas.

[10] To the extent that parts of these steep falls, and the associated increases in Q/K ratios, were a result of population in these states having reached a level that would allow greater utilisation of public infrastructure provided previously, there are limits to how far this type of sharp falls can continue. Eventually, as upper limits on the carrying/servicing capacity of existing infrastructure are reached, new public sector investment expenditures will be required, as has been recognised in recent regional planning documents for South East Queensland (See Office of Urban Management, 2005 and 2006).

various lines of enquiry together, with a view to consolidating our understanding of the dynamics involved.

As regards the determinants of the *level of GSP per capita* (Q/P), our results serve to confirm the critical importance of labour productivity (Q/L). A clear demonstration of this is the fact that the three states with highest Q/L ratios (WA, VIC, and NSW) were also those with highest Q/P ratios, and the three states with lowest Q/L ratios (SA, QLD, and TAS) also exhibited lowest Q/P ratios. Further, the case of QLD illustrates that even a high labour-to-population (L/P) ratio may be insufficient to offset the negative effects of a low Q/L ratio.

This naturally brings up the question of what, in turn, determines *labour productivity*. Of the two factors considered in this study, namely the capital-to-labour (K/L) ratio and the output-to-capital (Q/K) ratio, both have been found to exert powerful influences. In some cases, both factors worked in the same direction, contributing to either a high Q/L ratio (as in NSW) or to a low Q/L ratio (as in TAS). In other cases, they apparently conflicted, with mixed net outcomes (contrast WA with QLD).

Focusing then on the determinants of the *rate of growth in GSP per capita*, we found that the rate of growth in labour productivity played a dominant role, accounting on average for about three-quarters of total per-capita GSP growth in most states as well as Australia as a whole. Further, the relative importance of growth in labour productivity (as opposed to growth in the labour-to-population ratio) appears to have increased over time: the former represented around 80% of total per-capita GSP growth for Australia as a whole in the second half of the study period, compared with about 70 percent in the first half.

Narrowing the focus further to determinants of the *rate of growth in labour productivity*, it was found that both capital deepening (growth in the K/L ratio) and increases in the output-to-capital (Q/K) ratio were important. In the second sub-period, for which the capital stock data are considered more reliable, the contribution from each factor accounted for roughly one-half of the total growth in Q/L, but there were some interstate differences in the sizes of these shares.

In view of the important roles played the capital stock, it is of interest to ask whether the composition of the capital stock matters. While a definitive answer to this question must await a more formal treatment, from the present analysis it would appear that the private components of this stock, especially machinery and equipment (ME) and non-dwelling construction (NDC), may have been more influential on labour productivity and GSP per capita than the public component.

What policy implications can be drawn from these findings? One implication would be that if a state wished to raise its average level of income, it would need to raise labour productivity, through either capital deepening or increasing the output-to-capital ratio (or both). Further, it would appear that any given quantum of capital deepening would have a greater impact on labour productivity if it involved mainly the private ME and private NDC, rather than the public, components of the capital stock.

A natural follow-up question is how the output-to-capital ratio can be raised. At any point in time, there is some portion of the capital stock that is not utilised in the production process, just as there are some unemployed workers. Thus, the

Q/K ratio may rise either because capital capacity utilisation (K_u/K) increases, or because the productivity of the utilised units of capital (Q/K_u) increases, or both (here K_u stands for the total value of capital assets that are utilised). In turn, capital productivity may be increased through technological progress (including improvements in the way the production process is organised) or improvements in the quality of the labour associated with each unit of capital.

As for capacity utilisation, it is generally accepted that this variable moves cyclically, rising as aggregate demand increases and falling as economic activity decreases. But it is also possible that the K_u/K ratio in a particular state may be always lower (or higher) than in the other states throughout the various phases of the business cycle -- due to, for example, its business practices, the composition of its capital stock, or the industrial structure of its production. Seen under this light, the fact that both the Q/K and L/P ratios in TAS were low (and, further, that both ratios were either falling or relatively flat) suggests that the state's industrial structure may have predisposed it to relatively low rates of capital and labour utilisation. By contrast, both ratios were either high or rising in WA and QLD. Together, these observations point to a significant role for demand conditions, even in the medium-to-longer terms: the low utilisation rates in TAS may be attributable to its being less successful than, for example, WA and QLD in meeting changing trends in aggregate demand, especially export demands.

It is clear that a shortcoming of the current analysis is a lack of knowledge about interstate variations in the capital utilisation (K_u/K) rate. Without reliable estimates for K_u at the state level, it has not been possible to break down movements in the Q/K ratio into corresponding movements in the constituent ratios, Q/K_u and K_u/K. As a result, it remains unclear to what extent the remarkable rises in the Q/K ratio in WA and QLD have been due to gains in capital productivity, and to what extent they have been due to increased utilisation of previously accumulated capital assets. Similar questions remain about the performances of other states, indicating an area where further research may be useful.

Inevitably, the validity of many of the results reported in this paper is heavily dependent on the quality of the capital stock estimates used in the analysis. In this regard, we have made an effort to use these data with caution, and to refrain from placing too much emphasis on results which are likely to be very sensitive to such data. Despite such reservations, it would have been useful to have access to capital stock data *disaggregated by industrial sector* for each state. Data for both output (Q) and employed labour (L) are available by industrial sector, and exploration of the Q/K and K/L ratios for each industry could be of assistance to policymaking at the state level. Estimation of such disaggregated capital stock series awaits further research, as does the detailed analysis of industrial development and other policies that were pursued by the various states.

APPENDIX A: DATA SOURCES AND DERIVATION METHODS

Gross State (or Domestic) Product (GSP/GDP): Chain-volume measure (CVM) GSP/GDP data are obtained from the Australian Bureau of Statistics (ABS), Cat. No. 5220.0 *Australian National Accounts: State Accounts*, Table 1 (2004/05 edition, electronic form) for the period 1989/90 to 2004/05. Data for the period prior to 1989/90 are available in constant-price form (average 1989/90 prices) from the ABS, Cat. No. 5220.0 *Australian National Accounts: State Accounts* (1996/97 and 1995/96 printed editions). The earlier series are spliced onto the later series using the overlapping year of 1989/90.

Population: Quarterly data are obtained from the ABS, Cat. No. 3101.0 *Estimated Resident Population by States and Territories*, Table 4 (electronic) for the period 1988/89 to 2004/05. Data for the period prior to 1988/89 are obtained from the Econdata DX database (Version 3). To derive annual figures, the quarterly data are averaged over the four quarters of each financial year.

Number of Persons Employed: Monthly data for the total number of persons employed are obtained from the ABS, Cat. No. 6202.0.55.001 *Labour Force, Australia*, Table 12 (electronic form). Annual figures are derived by averaging over the 12 months of each financial year.

Total Number of Hours Worked: Monthly data for the total number of hours worked are obtained from the ABS, Cat. No. 6291.0.55.001 *Labour Force, Australia, Detailed, Electronic Delivery, Monthly* (electronic datacube). Annual figures are derived by averaging over the 12 months of each financial year. The original monthly data refer to the total number of hours worked in a representative week. Hence, the annual figures are multiplied by 52 to give the total number of hours worked in a given year.

Net Capital Stock: Estimates for various components of the net capital stock at the state level are obtained from Mikhailitchenko, et al. (2005).

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