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OKUN'S LAW AND MOVEMENTS OVER TIME IN THE UNEMPLOYMENT RATE IN AUSTRALIA

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1. Introduction

This article explains how movements in the unemployment rate reflect the relative rates of growth of employment and the labour force and are related to the participation rate, labour productivity growth and output growth. A framework is provided in which to analyse the determinants of movements in the unemployment rate.

We look at the unemployment rate and its relationship to labour force and employment growth in the next section. In section 3 we define the participation rate and discuss how it relates to labour force growth. Then in Section 4, we consider Verdoon's Law and the relationship between output growth and employment growth. In Section 5 we combine the results in the previous section to determine the relationship between the unemployment rate and output growth. Finally, in Section 6, we summarise the findings.

We begin looking at these questions by considering the way in which we measure the unemployment rate.

2. The Unemployment Rate, the Labour Force and Employment

When statistics are compiled for the labour market, people are classified either as being in the labour force or as being out of the labour force, and people in the labour force are classified as either employed of unemployed. The Australian Bureau of Statistics (ABS) estimates employment and unemployment in Australia from a monthly survey of households. It counts as employed any person aged 15 and over who worked for one hour or more in the week in which the survey was undertaken and who was paid for that work;[1] it counts as unemployed any person aged 15 and over who was not employed but who was actively seeking work and was available for work in the week in which the survey was undertaken. Anyone aged 15 or over who is not employed or unemployed is counted as being out of the labour force. To calculate the total number of persons employed, unemployed and out of the labour force in Australia, the ABS scales up the results from the survey (which covers about 60 thousand persons aged 15 or over) to the total population (which has about 15 million persons aged 15 or over), making adjustments for differences between the survey and the total population in factors such as age and gender composition.[2]

The ABS also defines two types of employment: full-time, defined as working more than 35 hours per week; and part-time, defined as working less than 35 hours per week. In this article our focus is on total employment but we should note that one of the most important trends in the Australian labour market over the last 20 years has been a substantial increase in part-time employment relative to full-time employment.

The *unemployment rate* is defined as the number unemployed divided by the number in the labour force (the number employed plus the number unemployed). Using the symbol *UR* for the unemployment rate, *U* for the number unemployed and *LF* for the number of persons in the labour force:

$$UR = U/LF. \tag{1}$$

Figure 1 shows the behaviour over time of the unemployment rate for persons in Australia in August of each year between 1964 and 1999.[3] Here, and elsewhere in this paper, all measures are expressed in percentage terms, that is, they will all be multiplied by 100.

[FIGURE 1 NEAR HERE]

The unemployment rate has tended to rise over the period. There are a number of very sudden and large increases in the unemployment rate: in 1975, in 1982–83, and in 1990–92. These are years in which the economy moved into recession. Following the recessions at the start of the 1980s and 1990s there was a slow fall in the unemployment rate associated with a recovery. This pattern illustrates an important feature of the labour market: unemployment rises rapidly yet tends to fall only slowly. There was no fall in unemployment after the rise in 1975. The mid-1970s was a period of transition between the 1960s and early 1970s, when the average unemployment rate was around two per cent, and the 1980s and 1990s, during which the unemployment rate was never below five per cent. Similar increases in the average unemployment rate occurred in a number of other countries and economists are still struggling to understand the reasons for these increases.

In this paper we are interested mainly in shorter-term changes in the unemployment rate. Let us begin by looking at how these relate to changes in employment and the labour force. Figure 2 shows year-on-year changes in the unemployment rate, which we denote by ΔUR, over the years 1965–99. (Since the data for *UR* begin in 1964 the earliest year for which we can compute a change in the unemployment rate is 1965.) We see in Figure 2 that there are high positive values of ΔUR in 1975, 1982, 1983, 1990, 1991 and 1992. As mentioned above, these years that exhibit a high ΔUR correspond with the movement of the economy into (or further into) recession.

To understand why the unemployment rate goes up or down it is useful to begin by rewriting our expression for the unemployment rate, equation (1), in terms of employment. Since the labour force is the sum of employment and unemployment, the number unemployed is the difference between the number of persons in the labour force and the number of persons employed, which we denote by *E*. That is, $U = LF - E$. Substituting this relationship into equation (1) gives:

$$UR = \frac{U}{LF} = \frac{LF - E}{LF} = 1 - \frac{E}{LF}. \tag{2}$$

The ratio, E/LF, is the proportion of the labour force who are employed, that is the *employment rate*.

The above expression tells us that the unemployment rate rises when employment decreases relative to the size of the labour force and that the unemployment rate falls when employment increases relative to the size of the labour force. Indeed, if we use the symbols ΔLF and ΔE for changes in the labour force and employment between two periods, then as we show in Appendix A, we may write as an approximation that:

$$\Delta UR \approx \frac{\Delta LF}{LF} - \frac{\Delta E}{E}, \tag{3}$$

where LF and E are the initial values of the labour force and employment, respectively. Dividing the change in a variable by its initial value gives the growth rate of the variable, so $\Delta LF/LF$ is the rate at which the labour force is growing and $\Delta E/E$ is the rate at which employment is growing.[4]

Equation (3) confirms that if employment rises faster (or falls more slowly) than the labour force ($\Delta E/E > \Delta LF/LF$) then the unemployment rate falls ($\Delta UR < 0$); and if employment rises more slowly (or falls faster) than the labour force ($\Delta E/E < \Delta LF/LF$) then the unemployment rate rises ($\Delta UR > 0$).

[FIGURE 2 NEAR HERE]

[FIGURE 3 NEAR HERE]

NOTE: IT IS BEST IF FIGURE 3 CAN APPEAR IMMEDIATELY BELOW FIGURE 2, AS IN THE MANUSCRIPT

Figure 3 shows the growth rates of the labour force and employment in each year between 1965 and 1999. As we would expect, the value of ΔUR was positive (the unemployment rose) in years when $\Delta E/E$ was below $\Delta LF/LF$ (we see this by comparing the points in Figure 3 with corresponding points in Figure 2). For example, in 1975, 1983 and 1991 there were relatively large (negative) discrepancies between $\Delta LF/LF$ and $\Delta E/E$, and we see from Figure 3 that in each of those years the unemployment rate rose quite markedly (that is, ΔUR was positive).

Figure 3 also reveals that there is a tendency for $\Delta LF/LF$ and $\Delta E/E$ to follow each other up and down—in other words, $\Delta LF/LF$ and $\Delta E/E$ are *positively correlated.* The correlation coefficient (usually this is denoted by the symbol r), between the rate of growth of employment and the rate of growth of the labour force over the period 1965–99 is +0.78.[5] One implication of this positive correlation is that high rates of employment growth usually do not produce large falls in the unemployment. Indeed the rate of growth in employment can be at a relatively high level and yet the unemployment rate may not fall, and may even rise.

The most dramatic examples of the unemployment rate rising in years when employment growth is high occurred in 1966, 1980 and 1986. Over the whole period, 1965–99, the average rate of employment growth ($\Delta E/E$) was 1.93 per cent per annum. In 1966 the rate of employment growth was 4.21 per cent, in 1980 it was 3.32 per cent and in 1986 it was 3.63 per cent, all considerably above the average. Yet, the corresponding values of ΔUR in those years were +0.40, 0.00 and +0.10 percentage points.[6] Equation (3) tells us that the unemployment rate falls only modestly or even rises when employment growth is high because, at the same time that employment is rising quickly, the labour force is also rising quickly, and this negates the effect we would otherwise see on the unemployment rate.

To understand why employment and the labour force tend to rise and fall together, we need to consider the participation rate—and especially the notion that the participation rate is pro-cyclical. This is examined in the next section.

3. A Simple Model of Labour Force Growth

The participation rate (*PR*) is the proportion of the (civilian) population of working age (*POP*) that is in the labour force.[7] That is, $PR = LF/POP$. This expression for the participation rate may be rearranged to yield an expression for the size of the labour force: $LF = PR \times POP$. In Appendix B we show that this implies that the growth rate of the labour force is approximately the sum of the growth rates of the participation rate and population:

$$\frac{\Delta LF}{LF} \approx \frac{\Delta PR}{PR} + \frac{\Delta POP}{POP}. \tag{4}$$

Figure 4 shows the growth rates of the labour force, the participation rate and the population for each year over the period 1965–99. Movements in the growth rate of the labour force are mainly driven by fluctuations in the participation rate and so to understand changes in the labour force we need to understand changes in the participation rate.

[FIGURE 4 NEAR HERE]

Figure 5 shows the time path for the participation rate in Australia over the period 1964–99. The participation rate has tended to rise over time,[8] but we can also see a cycle in the data with the participation rate rising as the economy recovers from a recession (see for example the period 1983–89) and remaining roughly constant or falling in recession periods (for example the periods 1980–83 and 1989–93).

[FIGURE 5 NEAR HERE]

Figure 6 compares the growth rate of the participation rate ($\Delta PR/PR$) with the growth rate of employment ($\Delta E/E$). Movements in the participation rate tend to mimic movements in employment. In other words, they are positively correlated. (The correlation coefficient between the rate of growth of employment and the rate of growth of the participation rate over the period 1965–99 is +0.77.) This means that the participation rate is *pro-cyclical*—it rises as output and employment growth rise and falls as output and employment growth fall. This pro-cyclical behaviour of the participation rate is the reason why the labour force tends to follow employment up and down.

[FIGURE 6 NEAR HERE]

The participation rate tends to be pro-cyclical because workers not previously in the labour force are encouraged to seek work (and hence be recorded by the ABS as unemployed or employed) in economic upturns, while in economic downturns many workers give up looking for work and are no longer counted in the labour force. Economists refer to this pattern as the *encouraged/discouraged worker effect* and to the existence of discouraged workers as *hidden unemployment*.

We have already noted one of the consequences of the encouraged worker effect and the pro-cyclical participation rate—that when employment growth starts to rise, the unemployment rate does not necessarily fall because a rise in the participation rate, and thus in the labour force, may act to offset the effect on the unemployment rate of the rise in employment. In Section 5 we shall look at the consequences of the encouraged worker effect for the relationship between output growth and unemployment. Before that, however, we need to consider the relationship between output growth and employment growth.

4. The Relationship between Employment Growth and Output Growth

Let Y be the level of aggregate output in real terms (for example, GDP measured at constant prices). We can define the average (physical) product of labour, APL, as the ratio of output to employment:[9]

$$APL = \frac{Y}{E}. \tag{5}$$

The average product of labour is often called *labour productivity*, or sometimes just productivity. Economists have often noted that movements in labour productivity tend to be positively correlated with movements in the level of output. This empirical generalisation—that there is a close (positive) relationship between the growth rate of output and the growth rate of the average product of labour - is called *Verdoorn's Law*.[10] Australian data is consistent with the relationship observed by Verdoorn. Figure 7 shows the rates of output growth and labour productivity growth in Australia over the period 1966–1999.[11] There is a clear tendency for productivity growth to follow output growth up and down—that is, the rates of output growth and labour productivity growth are positively correlated. The correlation coefficient between the rate of growth of output and the rate of growth of the average product of labour over the period 1965–99 is +0.69. We shall see that this implies that movements in output tend to have a smaller effect upon employment than would be the case in the absence of this induced increase in productivity.

[FIGURE 7 NEAR HERE]

Figure 7 also shows that there have been some years with negative output growth—most particularly 1978, 1983, 1991 and 1992. These were all years of recession—and, most importantly given the focus of this article, they were all years in which there were relatively large increases in the unemployment rate.

The definition of the average product of labour, equation (5) above, may be rearranged to yield an expression for the level of employment: $E = Y/APL$. This tells us that the level of employment in any period varies directly with the level of output and varies inversely with the average product of labour. In Appendix C we show that this implies that the growth rate of employment is approximately the difference between the growth rates of output and labour productivity:

$$\frac{\Delta E}{E} \approx \frac{\Delta Y}{Y} - \frac{\Delta APL}{APL}. \tag{6}$$

Equation (6) provides a useful framework for understanding and predicting the rate of employment growth.

Figure 8 shows movements over time in the growth rates of employment, output and labour productivity, whilst Figure 9 shows movements over time in the growth rates of employment and output alone.

[FIGURE 8 NEAR HERE]

[FIGURE 9 NEAR HERE]

As shown in Figures 8 and 9, the rate of growth of output in any period can be 'high' and yet the rate of growth of employment in that same period can be low and even negative. For example, the years 1969, 1974, 1984, 1996 and 1998 were all ones in which output grew considerable faster than 3.38 per cent per annum, the average over the period 1966–99, but they were all years in which employment grew comparatively slowly. In 1977 output rose by 4.0 per cent, faster than the average rate for the period, but employment fell by 0.7 per cent; and in 1982 output rose by 3.5 per cent but despite this, employment fell by 0.1 per cent.

High output growth can be associated with low or even negative employment growth because the increase in output induces an increase in the average product of labour (Verdoorn's Law) and this mutes the effect of an increase in output on employment. Indeed, as we have just seen, it is possible for all of the increase in output to be met, or even more than met, by efficiency or productivity improvements and for no increase in employment to be generated by the increase in output. When an economy moves out of recession but the output increase does not result in a growth in employment we refer to the situation as a *jobless recovery*. Jobless recoveries can occur because, as we have just seen, it is possible for the rate of growth of output to rise and yet employment to be unaffected (or even fall).

5. Output growth and the Unemployment Rate

In the previous section we talked about the effect of a change in output on employment but economists are also interested in the relationship between output growth and the unemployment rate. To understand this we need to use our knowledge of the relationship between employment growth and the unemployment rate from Sections 2 and 3.

To see the connection between output growth ($\Delta Y/Y$) and movements in the unemployment rate (ΔUR), substitute the expressions for the rate of growth of the labour force and employment, equations (4) and (6), into the expression for the change in the unemployment rate, equation (3), to give:

$$\Delta UR = \frac{\Delta LF}{LF} - \frac{\Delta E}{E} = \left[\frac{\Delta PR}{PR} + \frac{\Delta POP}{POP}\right] - \left[\frac{\Delta Y}{Y} - \frac{\Delta APL}{APL}\right]. \tag{7}$$

Movements in the unemployment rate over time (ΔUR) reflect the relative magnitudes of population growth ($\Delta POP/POP$), movements in the participation rate ($\Delta PR/PR$), the growth rate of real output ($\Delta Y/Y$) and the rate of growth in labour productivity ($\Delta APL/APL$).

Given equation (7), it follows that if the growth rates of population, the participation rate and the average product of labour were unrelated to the growth rate of output, then the unemployment rate would tend to fall when the growth rate of output was high. As noted above, it is reasonable to assume that population growth is unrelated in the short term to output growth. But we saw in Section 4 that labour productivity growth tends to be high when output growth is high (Verdoorn's Law). So the effect of high output growth on the unemployment rate will often be offset by the effect of high labour productivity growth. When this does not happen, unemployment growth will be high—see equation (6). We saw in Section 2 that labour force growth tends to be high when employment growth is high because of an increase in the participation rate (Section 3). So if the effect on the unemployment rate of high output growth is not offset by the effect of high labour productivity growth, then it is likely to be offset by the effect of a rapid increase in the labour force and the participation due to a high growth rate of employment.

The existence of these offsetting effects mean that there is no simple and stable connection between output growth and unemployment. It is possible to have a recovery of output from a recession without a rise in employment and/or a fall in the unemployment rate and indeed we have seen this on a number of occasions in Australia. For example, market-sector GDP grew by 6.1 per cent in real terms in 1967, by 6.75 per cent in 1974, by 4.00 per cent in 1977, by 3.52 per cent in 1982 and by 5.27 per cent in 1996, all above the average of 3.38 per cent per annum over the period 1966–99. Yet in every one of those years the unemployment rate increased - by 0.1 percentage points in 1967, by 0.6 percentage points in 1974, by 1.0 percentage points in 1977, by 1.1 percentage points in 1982 and by 0.4 percentage points in 1996. So there is no simple connection between fast output growth and large reductions in the unemployment rate.

[FIGURE 10 NEAR HERE]

Figure 10 shows the time path of changes in the unemployment rate (ΔUR) and the growth rate of output ($\Delta Y/Y$). In each episode in which the unemployment rate has fallen markedly (1984–85, 1988–89, 1994–95 and 1998–99) output growth has been high; likewise in each episode in which the unemployment rate has risen markedly (1975, 1983 and 1991–92) output growth has been low or negative. So there does appear to be an inverse relationship between the rate of growth of output and movements in the unemployment rate, but this negative relationship is not true at all times and the strength if the relationship also varies over time.

We can see the relationship between changes in the unemployment rate and the growth rate of output more clearly from Figure 11, which shows a scatter diagram for the two variables (ΔUR and $\Delta Y/Y$) using Australian data over the period 1966–99. The two do seem to be inversely related but the unemployment rate tends to vary less than the growth rate of output and there is a good deal of 'scatter' or 'noise' in the relationship.

[FIGURE 11 NEAR HERE]

The negative relationship between the unemployment rate and output growth is known as *Okun's Law*. Okun's Law is named after Arthur Okun, an economist who was for some time a member of the influential Council of Economic Advisers (to the U.S. President).[12] He observed for the U.S. a negative relationship between the unemployment rate and output growth such that a one percentage point decrease in the unemployment rate was accompanied by a three per cent increase in the rate of growth of output and he felt that this relationship was sufficiently reliable that it might be used for forecasting and policy purposes (Okun, 1962).

A simple form of Okun's Law asserts that equation (7) can be reduced to:

$$\Delta UR = a + b\frac{\Delta Y}{Y}. \qquad (8)$$

If we fit this line to the data in Figure 11, the line has a slope of –0.22. This implies that on average a 4.5 per cent increase in the growth rate of output is required to reduce the unemployment rate in Australia by one percentage point.[13] Watts and Mitchell (1991) also arrived at this figure for Australian data.

However, we know that the quantitative link between changes in output and the unemployment rate, as summarised in the coefficient b, reflects the influence of $\Delta Y/Y$ on $\Delta E/E$ adjusting for the effects of $\Delta Y/Y$ on $\Delta APL/APL$ and also the effect of $\Delta E/E$ on $\Delta LF/LF$ through the effect of $\Delta E/E$ on $\Delta PR/PR$. It is because of this that we should not expect there to be any precise and stable relationship between the two as we know that the links between $\Delta Y/Y$ and $\Delta E/E$ on the one hand, and $\Delta E/E$ and $\Delta LF/LF$ on the other, are tenuous and indeed are often such that a rise in $\Delta Y/Y$ need not in theory, and occasionally does not in fact, lead to a fall in UR. Thus it is not surprising to find little reliance on Okun's Law for policy-making purposes in Australia and other countries.

Okun found that for the U.S. an increase in the growth rate of GDP of three per cent would tend to be associated with a fall in the unemployment rate of one per cent. Some people, when asked to state Okun's Law, would give this quantitative rule. However, it is better to state the law more generally and to see Okun as reminding us about something more complex than this simplistic rule suggests. A more general statement of the law is the following:

> *An increase (decrease) in the rate of growth of output by one percentage point will not reduce (increase) the unemployment rate by one percentage point but instead it will increase (decrease) by only some fraction of one percentage point. This is because induced movements in labour productivity mute the effects of output growth on employment growth and also because employment growth in turn induces a change in the participation rate and thus the size of the labour force which mutes the effect of employment growth on the unemployment rate.*

6. Conclusion

The unemployment rate is the fraction of the labour force that is unemployed, and the labour force consists of persons aged 15 or over who are either employed or unemployed. Given this, the change in the unemployment rate is approximately equal to the difference between the rates of growth of the labour force and employment. Since these growth rates are positively correlated, it is possible for the unemployment rate to increase even when employment growth is high.

The participation rate is the fraction of the adult population that is in the labour force (whether they are employed or unemployed). The participation rate is pro-cyclical—that is, it tends to rise quickly when employment and output growth are high and to rise slowly, or even fall, when employment and output growth are low or negative. This is the reason the labour force and employment growth are positively correlated. In particular it explains why the unemployment rate does not always fall when employment growth that has been low or negative in a recession finally starts to rise.

The growth rate of employment is approximately equal to the difference between the growth rates of output and labour productivity. The growth rates or output and labour productivity are positively correlated—that is, a high growth rate of output tends to induce an increase in labour productivity. This relationship is known as Verdoorn's Law. Because of Verdoorn's Law, it is possible to have rapid growth in output as the economy recovers from a recession without a matching rise in employment.

The unemployment rate tends to fall when output growth is high and to rise when output growth is low. But the magnitudes of changes in unemployment are usually much smaller than the changes in the growth rate of output. This is known as Okun's Law. The unemployment rate depends on many factors apart from output growth and, for Australia, the relationship given by Okun's Law is probably too crude to be of much help in forecasting and policy making. Indeed there have been several occasions when output growth has been high by historical standards but the unemployment rate has remained the same or has increased, rather than decreased.

APPENDIX A: Determinants of changes in the unemployment rate

The size of the labour force in period t is equal to the size of the labour force in period $t-1$ plus the change in the labour force between period $t-1$ and period t. That is, $LF_t = LF_{t-1} + (LF_t - LF_{t-1})$ or $LF_t = LF_{t-1} + \Delta LF_t$, where we have used the symbol Δ to indicate the change between the previous period and the current period. In a similar manner we can write employment in period t as $E_t = E_{t-1} + \Delta E_t$. Therefore, we can use the definition of the unemployment rate in equation (1) to write the change in the unemployment rate between period $t-1$ and period t as:

$$\Delta UR_t = UR_t - UR_{t-1} = \frac{E_{t-1}}{LF_{t-1}} - \frac{E_t}{LF_t}.$$

We can write the ratio of employment to the labour force in period t as:

$$\frac{E_t}{LF_t} = \frac{E_{t-1} + \Delta E_t}{LF_{t-1} + \Delta LF_t} = \frac{E_{t-1}(1 + \Delta E_t / E_{t-1})}{LF_{t-1}(1 + \Delta LF_t / LF_{t-1})} = \frac{E_{t-1}}{LF_{t-1}} \times \frac{1 + \Delta E_t / E_{t-1}}{1 + \Delta LF_t / LF_{t-1}}.$$

If we substitute this into the expression for the change in the unemployment rate above we get:

$$\Delta UR_t = \frac{E_{t-1}}{LF_{t-1}} \left[1 - \frac{1 + \Delta E_t / E_{t-1}}{1 + \Delta LF_t / LF_{t-1}} \right] = \frac{E_{t-1}}{LF_{t-1}} \left[\frac{\Delta LF_t / LF_{t-1} - \Delta E_t / E_{t-1}}{1 + \Delta LF_t / LF_{t-1}} \right].$$

The product of the denominators in the two parts of this expression is $LF_{t-1} + \Delta LF_t$, which equals LF_t. Therefore the change in the unemployment rate is

$$\Delta UR_t = \frac{E_{t-1}}{LF_t} \left[\frac{\Delta LF_t}{LF_{t-1}} - \frac{\Delta E_t}{E_{t-1}} \right].$$

If employment in period $t-1$ is approximately equal to the labour force in period t, then:

$$\Delta UR_t \approx \frac{\Delta LF_t}{LF_{t-1}} - \frac{\Delta E_t}{E_{t-1}}.$$

This is the approximation we use in equation (3) in the text. In general E_{t-1}/LF_t will be less than one, so the approximation will overstate the magnitude of the change in the unemployment rate. However, and this is the most important property for our purposes, E_{t-1}/LF_t will be positive so the approximation will always have the same sign as the change in the unemployment rate.

APPENDIX B: The relationship between the growth rate of the labour force, the participation rate and population

We saw in Section 3 that in any period, the labour force is equal to the product of the participation rate and population. In symbols, this is $LF_t = PR_t \times POP_t$. Now following the same procedure as we used in Appendix A, we can write the labour force in period t in terms of the labour force in period $t-1$ and the change in the labour force between the two periods, ΔLF_t:

$$LF_t = LF_{t-1} + \Delta LF_t = LF_{t-1} + LF_{t-1} \times \frac{\Delta LF_t}{LF_{t-1}} = LF_{t-1}\left[1 + \frac{\Delta LF_t}{LF_{t-1}}\right].$$

If we write the participation rate and population in terms of growth rates in the same way and substitute the expressions into relationship between the labour force, the participation rate and population, we get:

$$LF_{t-1}\left[1 + \frac{\Delta LF_t}{LF_{t-1}}\right] = \left\{PR_{t-1}\left[1 + \frac{\Delta PR_t}{PR_{t-1}}\right]\right\} \times \left\{POP_{t-1}\left[1 + \frac{\Delta POP_t}{POP_{t-1}}\right]\right\}.$$

Now, since $LF_t = PR_t \times POP_t$, we can divide the left-hand side of this equation by LF_t and divide the right-hand-side by $(PR_t \times POP_t)$ to get:

$$1 + \frac{\Delta LF_t}{LF_{t-1}} = \left[1 + \frac{\Delta PR_t}{PR_{t-1}}\right] \times \left[1 + \frac{\Delta POP_t}{POP_{t-1}}\right].$$

Finally, if we expand out the brackets on the right-hand side and subtract one from both sides, we get:

$$\frac{\Delta LF_t}{LF_{t-1}} = \frac{\Delta PR_t}{PR_{t-1}} + \frac{\Delta POP_t}{POP_{t-1}} + \left[\frac{\Delta PR_t}{PR_{t-1}}\right] \times \left[\frac{\Delta POP_t}{POP_{t-1}}\right].$$

This formula tells us that the growth rate of the labour force equals the growth rate of the participation rate *plus* the growth rate of the population, *plus* the cross product of the growth rates of the participation rate and population. Now, if the growth rates of the participation rate and population are both small, then the cross-product term will be small relative to the other terms in the formula, and we can write:

$$\frac{\Delta LF_t}{LF_{t-1}} \approx \frac{\Delta PR_t}{PR_{t-1}} + \frac{\Delta POP_t}{POP_{t-1}}.$$

This is equation (4) in the text.

To give an example, if the growth rate of the participation rate is one per cent (0.01) and the population growth rate is two per cent (0.02), then the cross-product term is $0.01 \times 0.02 = 0.0002$. We can calculate the growth rate of the labour force using the exact formula: $0.01 + 0.02 + 0.0002 = 0.0302$, or 3.02 per cent. If we use the approximation, we get $0.01 + 0.02 = 0.03$, or 3.00 per cent, which is quite close to the correct value. Note that the approximation may not be very good if the growth rates of the participation rate and population are not small. For example, if the growth rate of the participation rate is one hundred per cent (1.00) and the population growth rate is fifty per cent (0.50), then the cross-product term is $1.00 \times 0.50 = 0.50$. The correct growth rate of the labour force from the exact formula is $1.00 + 0.50 + 0.50 = 2.00$, or 200 per cent, but the value from the approximate formula is $1.00 + 0.50 = 1.50$, or 150 per cent, which is not very close to the correct value.

The result we have just derived is a special case of the general rule for the growth rates of a product. If one variable, z, is the product of two other variables, x and y, then the growth rate of z is approximately the sum of the growth rates of x and y, provided the growth rates of x and y are small. In symbols this says:

$$z_t = x_t \times y_t \quad \Rightarrow \quad \frac{\Delta z_t}{z_{t-1}} \approx \frac{\Delta x_t}{x_{t-1}} + \frac{\Delta y_t}{y_{t-1}}.$$

APPENDIX C: The relationship between the growth rates of employment, output and labour productivity

We saw in Section 4 that employment is equal to output divided by the average product of labour. That is, $E_t = Y_t / APL_t$. To find the approximate relationship between the growth rates of employment, output and labour productivity, all we need do is rewrite the equation as $Y_t = APL_t \times E_t$. Then we can use the product rule for growth rates that we derived in Appendix B:

$$\frac{\Delta Y_t}{Y_{t-1}} \approx \frac{\Delta APL_t}{APL_{t-1}} + \frac{\Delta E_t}{E_{t-1}}.$$

Rearranging this expression gives us the approximation in equation (6) in the text:

$$\frac{\Delta E_t}{E_{t-1}} \approx \frac{\Delta Y_t}{Y_{t-1}} - \frac{\Delta APL_t}{APL_{t-1}}.$$

This is an example of a general rule for the growth rates of a quotient:

$$y_t = \frac{z_t}{x_t} \quad \Rightarrow \quad \frac{\Delta y_t}{y_{t-1}} \approx \frac{\Delta z_t}{z_{t-1}} - \frac{\Delta x_t}{x_{t-1}}.$$

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FIGURES

Figure 1: The Unemployment Rate (Australia: Persons, August 1964- August 1999)

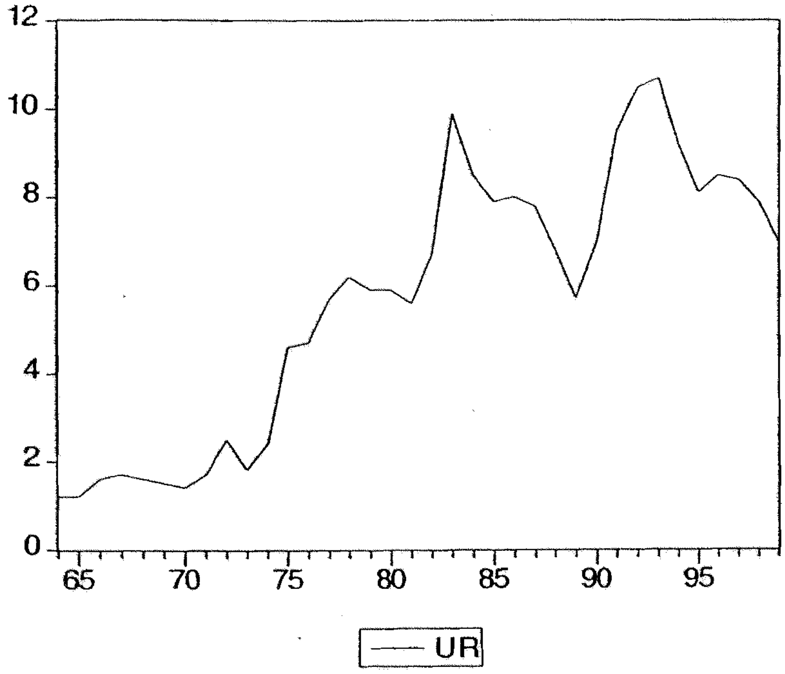


Figure 2: Year on Year Changes in the Unemployment Rate (ΔUR) 1965 - 1999

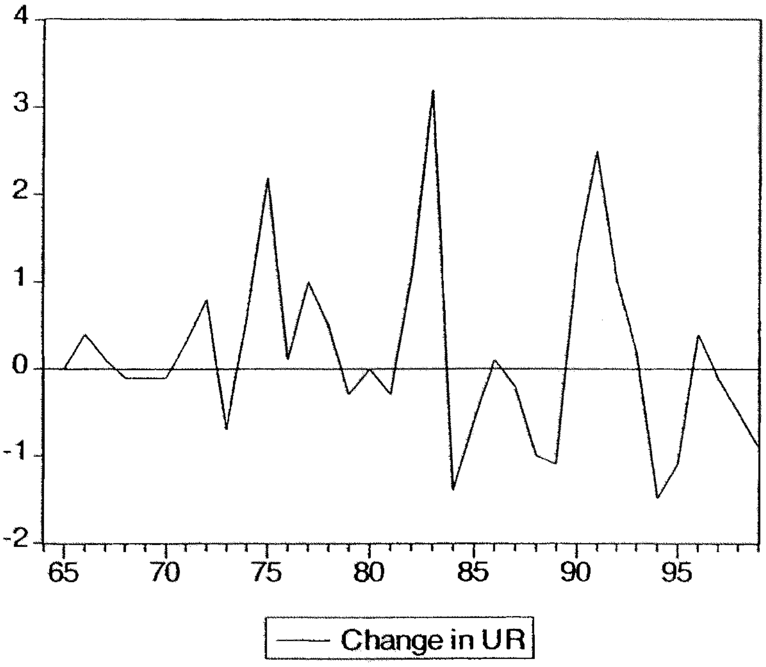


Figure 3: The Rates of Growth of Employment (ΔE/E) and the Labour Force (ΔLF/LF)

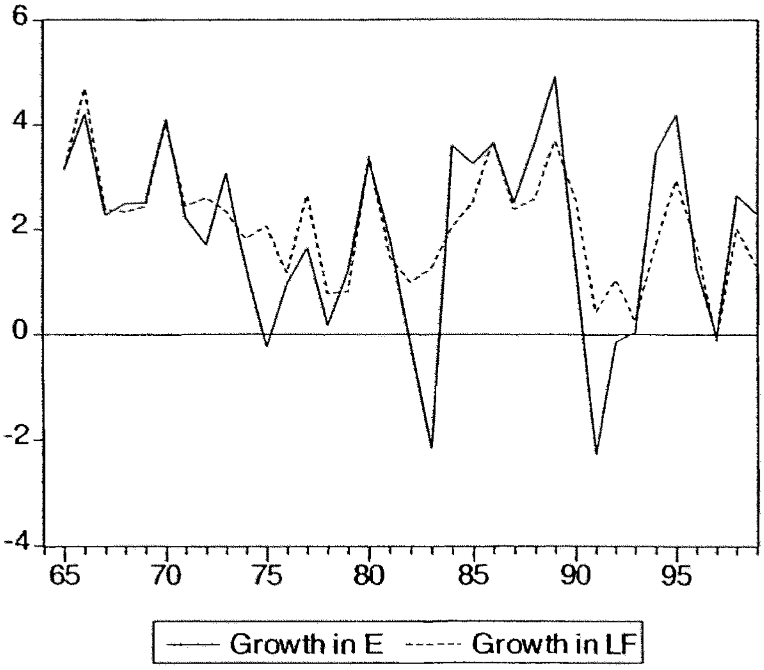


Figure 4: The Rates of Growth of the Labour Force (ΔLF/LF), the Participation Rate (ΔPR/PR) and Population (ΔPOP/POP)

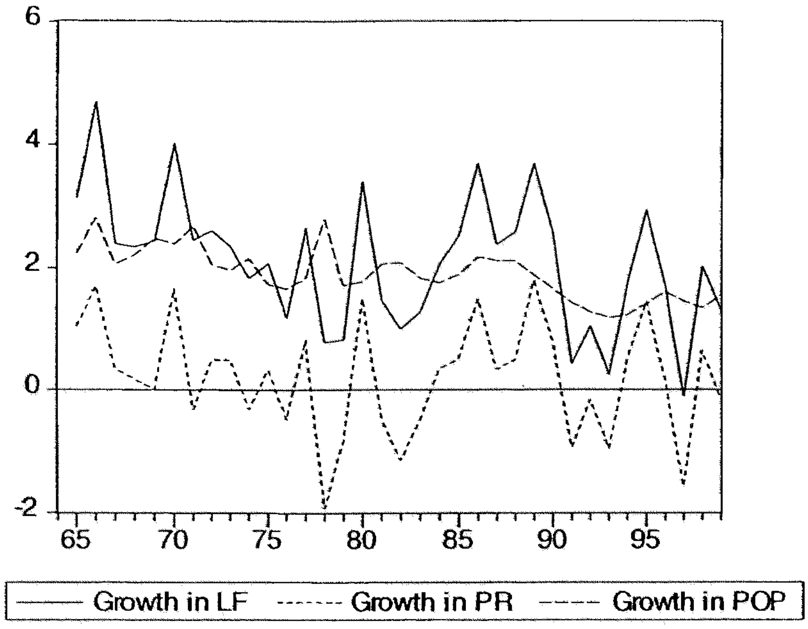


Figure 5: The Participation Rate (PR) for Persons (1964-1999)

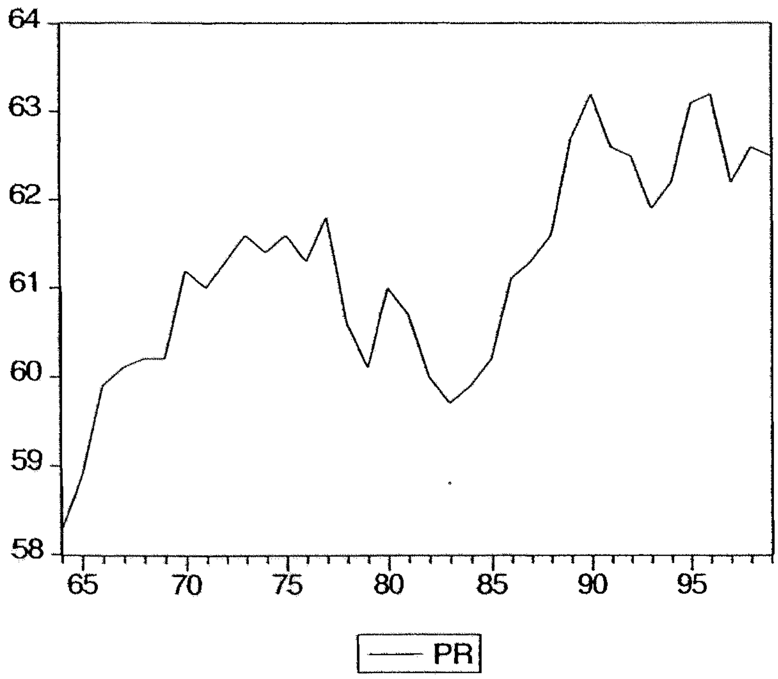


Figure 6: The Rates of Growth of the Participation Rate (ΔPR/PR) and Employment (ΔE/E)

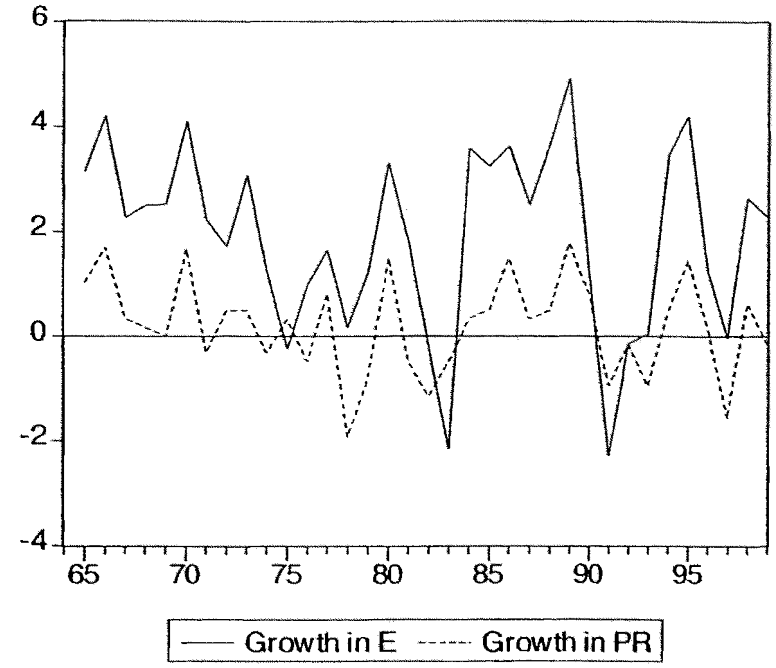


Figure 7: The Rates of Growth of Output (ΔY/Y) and Labour Productivity (ΔAPL/APL)

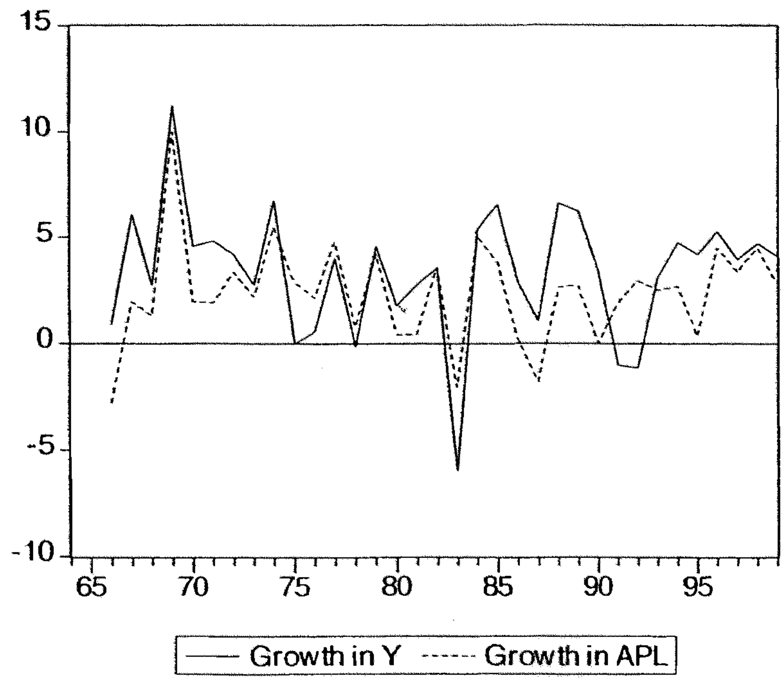


Figure 8: The Rates of Growth of Employment ($\Delta E/E$), Output ($\Delta Y/Y$) and Labour Productivity ($\Delta APL/APL$)

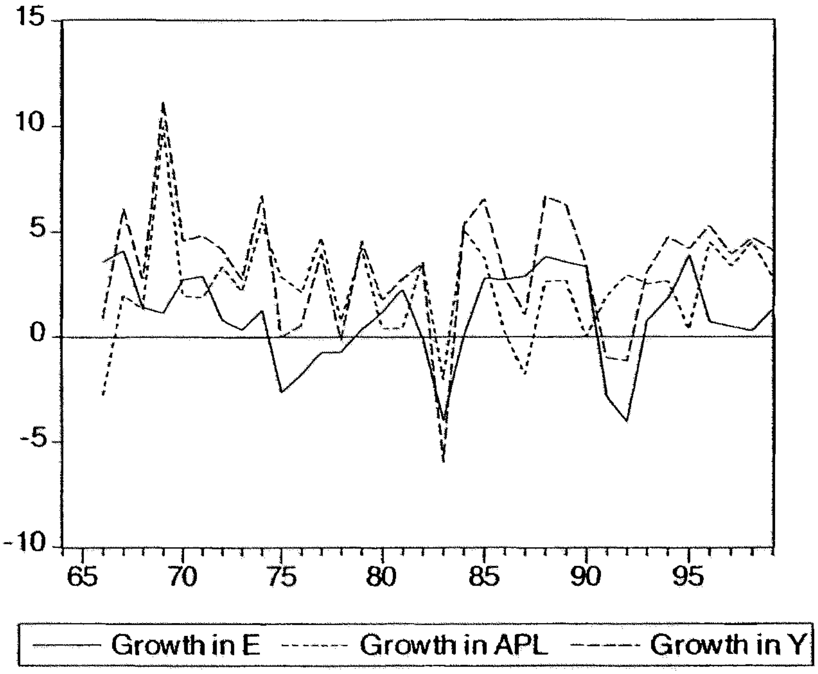


Figure 9: Relative Growth Rates of Employment ($\Delta E/E$) and Output ($\Delta Y/Y$)

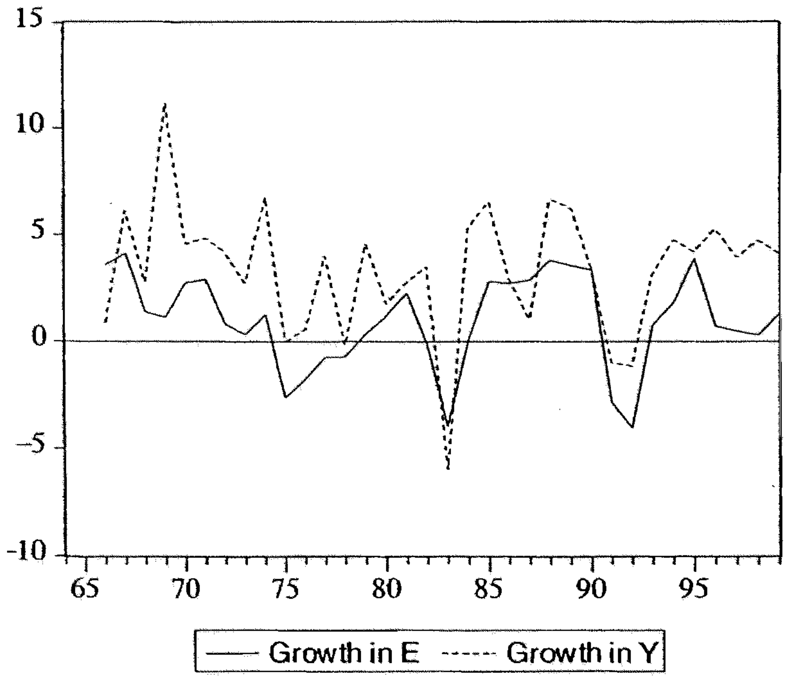


Figure 10: Time paths of Change in the Unemployment Rate (ΔUR) and the Rate of Growth of Output ($\Delta Y/Y$)

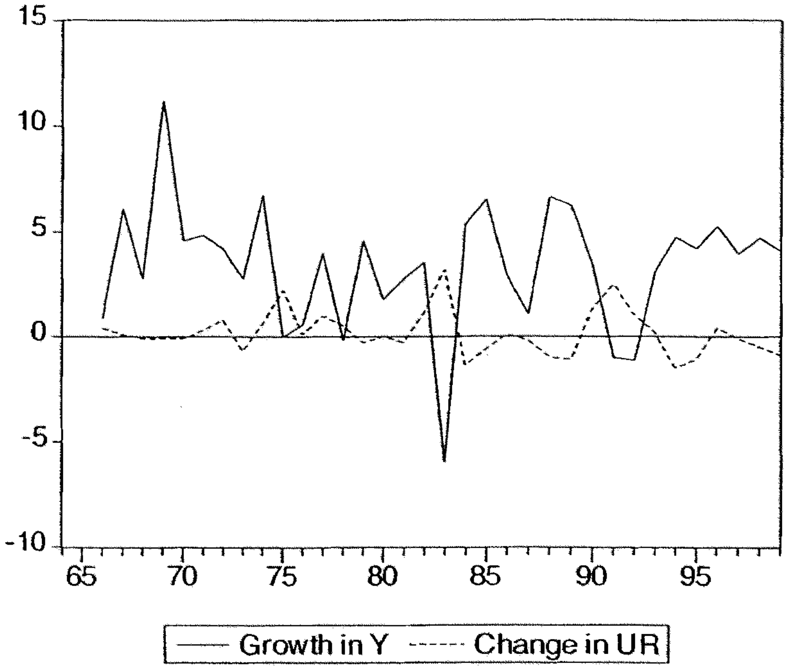
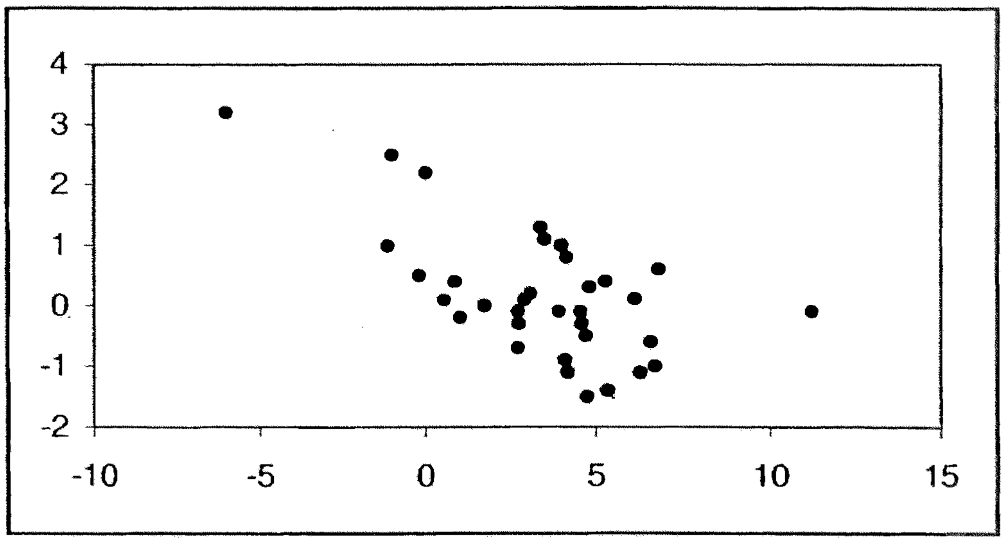


Figure 11: Scatter Diagram for ΔUR (Vertical axis) and $\Delta Y/Y$ (Horizontal axis)



[1] Employment also includes persons who work in a family business, even if the work is unpaid.
[2] It is common to exclude members of the armed forces from the measures of employment and the labour force so that when people use these terms they are usually referring to 'civilian employment' and the 'civilian labour force'.
[3] The source of the data is ABS, *Labour Statistics*, Australia, Cat. No. 6101.
[4] For example, if E were 100 in one year and 103 in the next year, ΔE would be 3 and the rate of growth between the two years, $\Delta E/E$, would be 3/100 = 0.03 or 3 per cent. Note that growth rates can, in principle, be negative.
[5] Recall that if two variables are perfectly positively correlated (they move perfectly in step) then the correlation coefficient between them equals +1.0; if the two variables are uncorrelated (their movements are independent of each other) then the correlation coefficient equals 0.0; and if the two variables are perfectly negatively correlated (the two variables move exactly in opposite directions) then the correlation coefficient equals -1.0.
[6] There were also periods when employment growth was at a historically high level and yet the unemployment rate fell only a little. An example of this occurred in 1970 when the rate of growth in employment was 4.11 per cent yet the unemployment rate fell by only 0.1 percentage points.
[7] The ABS defines the participation rate as the ratio of the labour force to the civilian population aged 15 and over. Some other agencies, such as the OECD, define the participation rate as the ratio of the labour force to the population aged 15 to 64.
[8] In the last two decades, there has been a fall in the participation rate of males that has been more than offset by a rise in the participation rate of females. In the year 1998/99 the average participation rate for males was 73 per cent and for females was 54 per cent. (Source ABS, *Australian Economic Indicators*, Cat. No. 1350.0, January 2000, pp 80–2.)
[9] This is the average product or labour productivity per worker. An alternative definition of the average product of labour that is often used is the ratio of production to total hours worked.
[10] Petrus Verdoorn was an economist with the Economic Commission for Europe, based in Geneva. He published a paper in Italian in 1949 in which he used this empirical generalisation to predict post-war levels of productivity growth in Europe. His ideas have been used by the Cambridge economist, Nicholas Kaldor. For further information on Verdoorn's Law see Kaldor (1966) and O'Hara ed. (1999, pp 1228–31).
[11] The source of the data is the ABS, *Australian System of National Accounts*, Cat. No. 5204.0, 1998–99, Table 1.17. The data used in Figure 7 refer to the so-called 'Market Sector' of the economy, which excludes the Property and Business Services sector, the Government Administration and Defence sector, the Education, Health and Community Services sector and the Personal & Other Services sector. These sectors are excluded because the way in which the ABS calculates the output of these sectors makes it impossible to derive meaningful productivity measures for the sectors. Note that labour productivity is measured as output per hour rather than as output per worker.
[12] For further information about Okun and his 'law', see O'Hara (ed.) (1999, pp 819–21) and Pechman (ed.) (1983, pp vi–xii). For an exposition in the Australian context see Indecs (1995, pp 76–9).
[13] Can you see how this figure is arrived at? Hint: What does the inverse of 0.22 tell us?

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