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What is happening to traditional apprentice completions?

TOM KARMEL
GURJINDER VIRK

NATIONAL CENTRE FOR
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Level 11, 33 King William Street, Adelaide, SA 5000
PO Box 8288 Station Arcade, Adelaide SA 5000, Australia

ph +61 8 8230 8400 fax +61 8 8212 3436
email ncver@ncver.edu.au
<http://www.ncver.edu.au>
<http://www.ncver.edu.au/publications/1724.html>

Abstract

This paper models completions for traditional apprenticeships on the basis of commencements in earlier quarters. These models are used to understand the dynamics of the relationship between these two variables in order to predict future completions. On the basis of the models, it is expected that completions of traditional apprenticeships will increase over coming quarters. The models also allow us to comment on the variation in completion rates across states and changes in them over time.

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Tables

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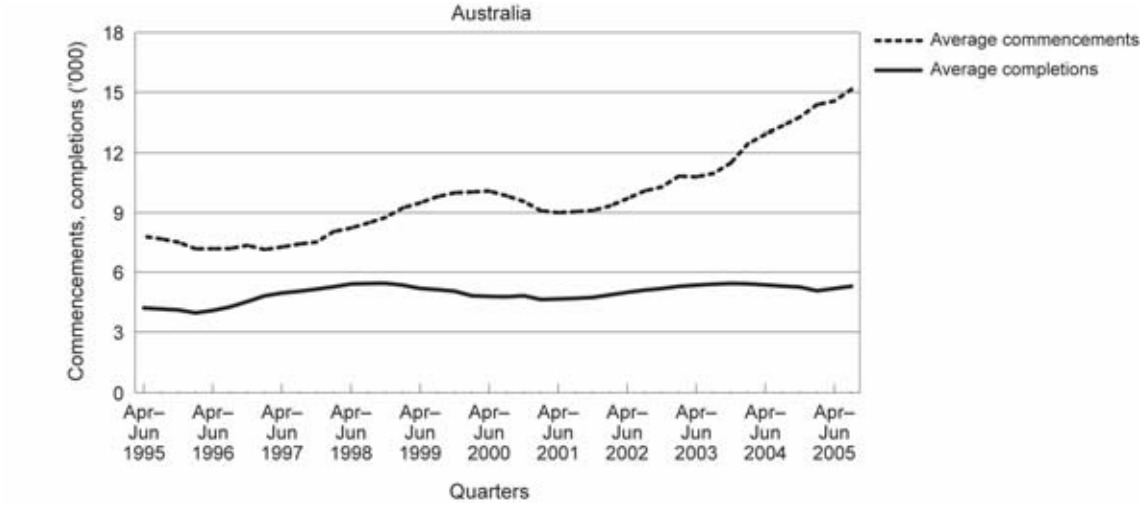
What is happening to traditional apprentice completions?

A major feature of the apprentice and traineeship data over the last couple of years has been the substantial growth in the numbers of commencements in traditional apprenticeships.[1] This, in all likelihood, has been driven by the buoyant labour market together with the considerable publicity given to skill shortages in the traditional trades. However, a noticeable feature of the data (see figure 1) has been no corresponding increase in the numbers of completions.

Figure 1 Commencements and completions for traditional apprenticeships (smoothed), Australia, 1995–2005



Source: Apprentice and Trainee Collection 46 (NCVER)

One possible explanation is that the time taken to complete a traditional apprenticeship has meant that the increase in commencements has not yet had time to flow through to the number of completions. A second explanation is that completion rates have declined, possibly because of the many opportunities available in the labour market for those part-way through their training. The purpose of the paper is to throw some light on these possible explanations, by modelling the relationship between completions and commencements. This will also assist in understanding the dynamics of the relationship. The models also enable us to comment on the differences between states and on likely movements in completions over coming quarters.

We first outline the methodology. Initial results are provided, followed by an investigation of whether the relationship has changed over time. Based on the model for the period 2002–05, we then provide predictions for coming quarters. A brief discussion of the results precedes the conclusion.

[1] Contracts identified as 'traditional apprenticeships' are defined as those contracts in the trades and related workers occupational group at Australian Qualifications Framework level III qualification or above, with more than two years expected duration for full-time contracts and more than eight years expected duration for part-time or school-based contracts. It should be noted that occupation coding of apprentices and trainees can vary between states and territories.

Methodology

The approach we take is to fit simple statistical time series models to the data. Essentially, we know that a certain proportion of commencements in one quarter will end up as completions in another quarter. More formally, we model completions in one quarter as the sum of proportions of commencements in previous quarters. We know that the duration of apprenticeships is up to four years, so we allow for 17 quarterly lags. That is,

$$completions_t = \sum_{i=1}^{17} \alpha_{t-i} commencements_{t-i}$$

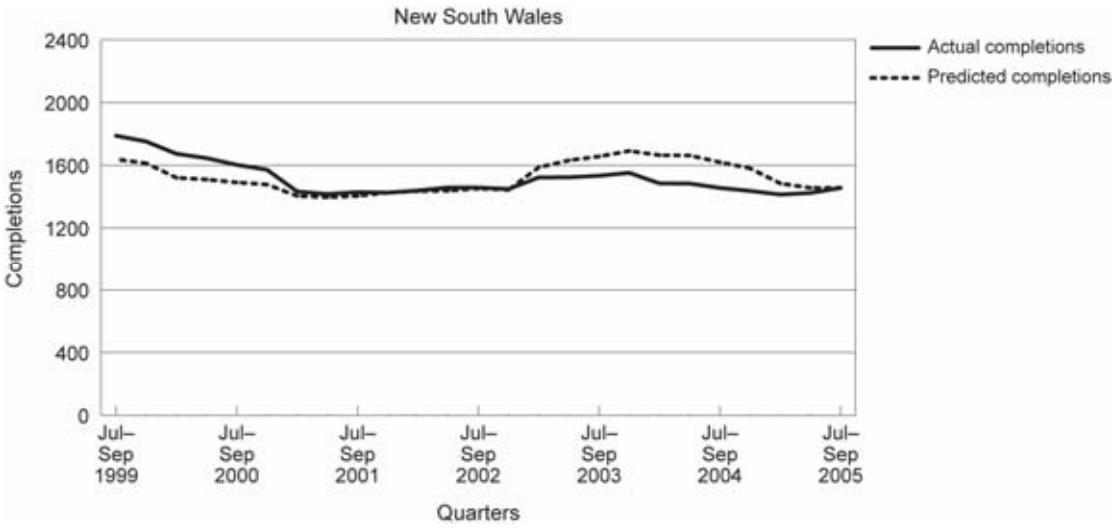
where t is the quarter in question. These models are fitted for each state, to allow for different industry bases, as well as possible differences in administrative practices and legislative frameworks. We then simplify the model by dropping the α coefficients that are not significant. The final models are at appendix 1.

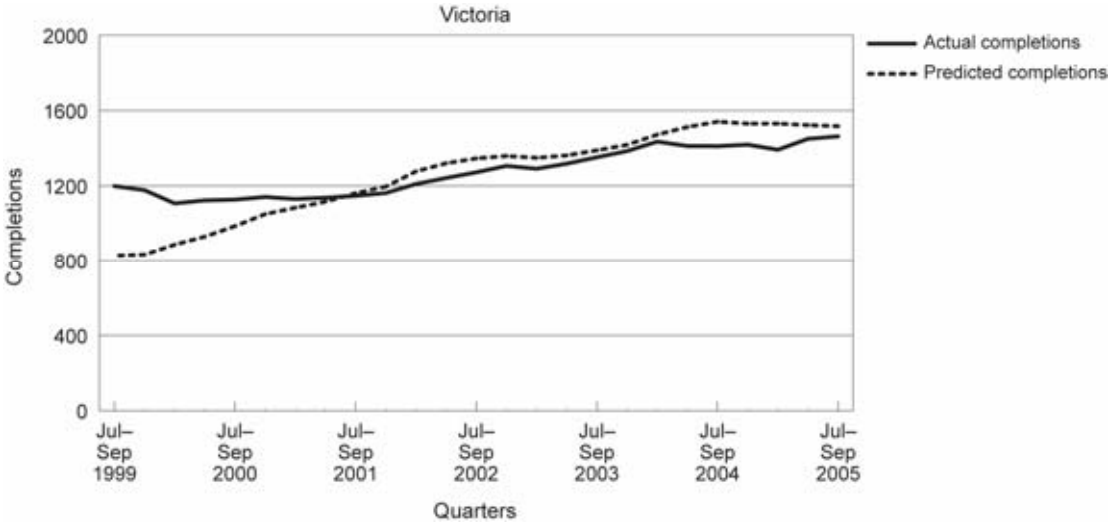
The αs have a simple interpretation. They are the proportion of commencements that are completed after i quarters. By summing them over all quarters, we obtain an implied overall completion rate.

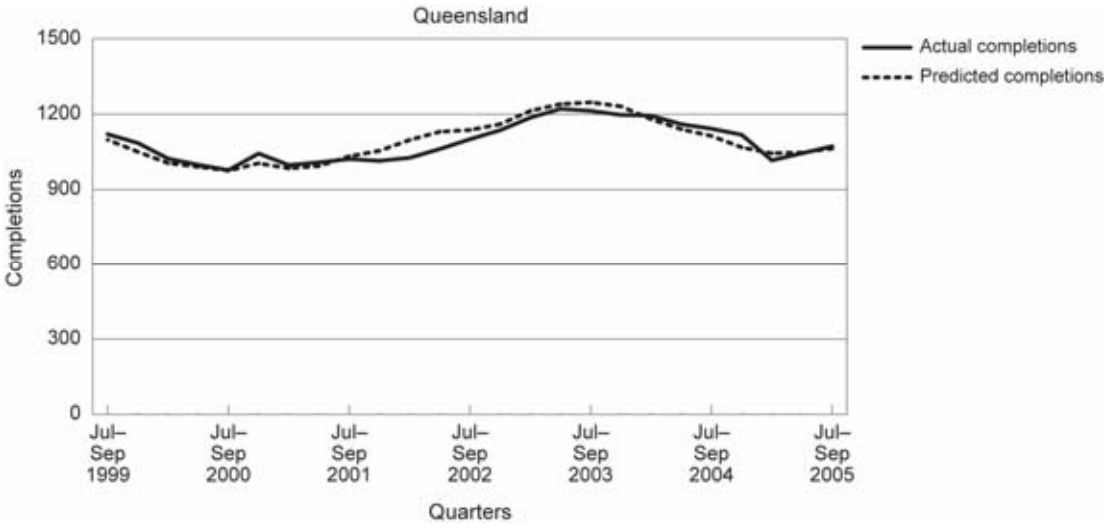
Initial results

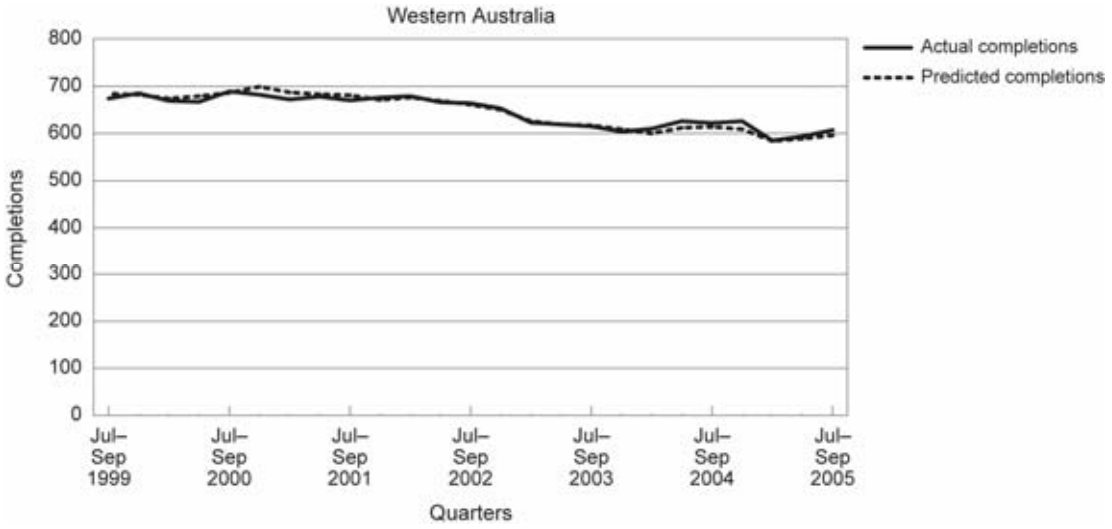
The easiest way of illustrating the fit of the models is by plotting the actual data with the predictions. To make it easier to see the underlying patterns, we have smoothed the data over four quarters to remove noise and seasonality (figure 2).

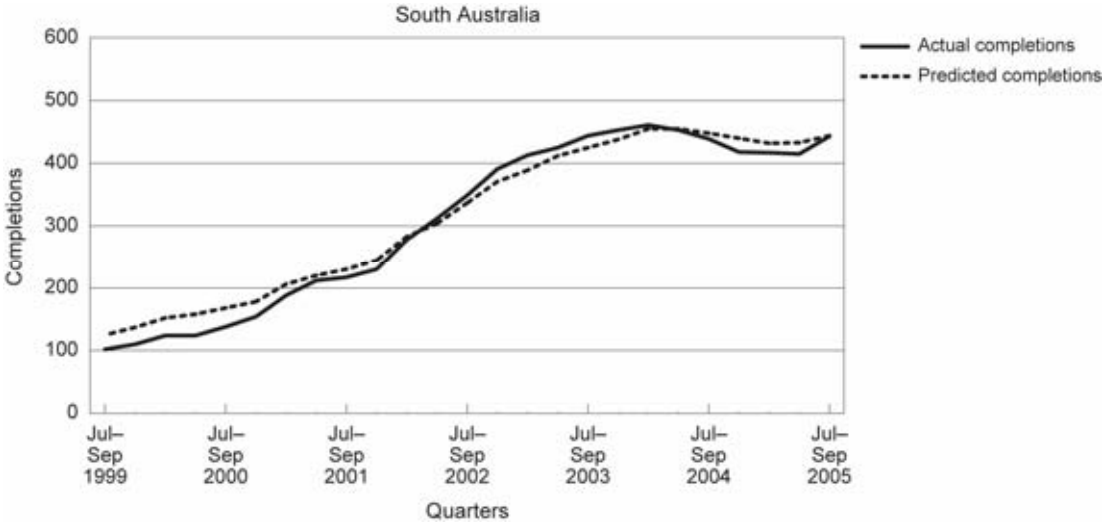
Figure 2 Actual and predicted completions for traditional apprentices, states and territories, 1999–2005

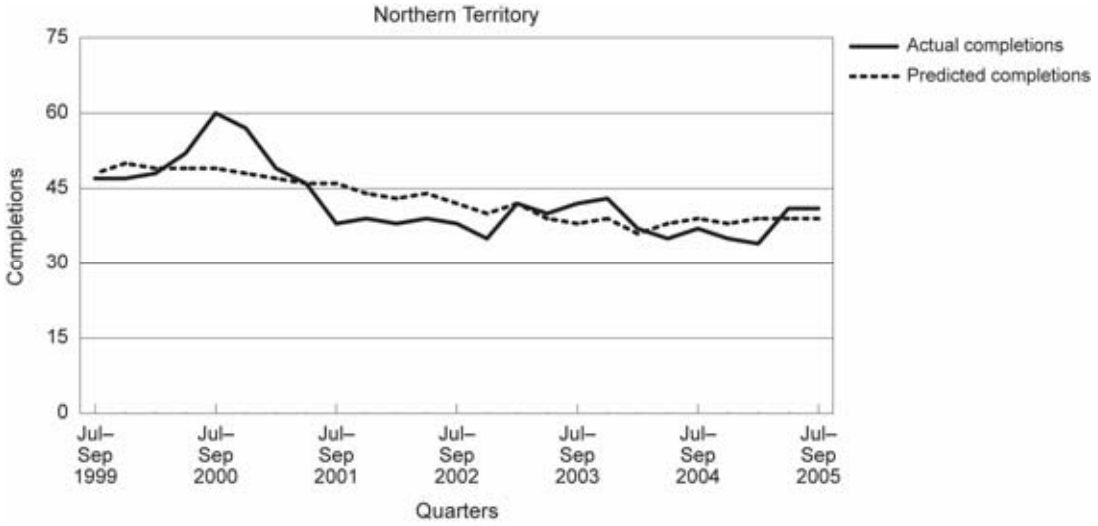


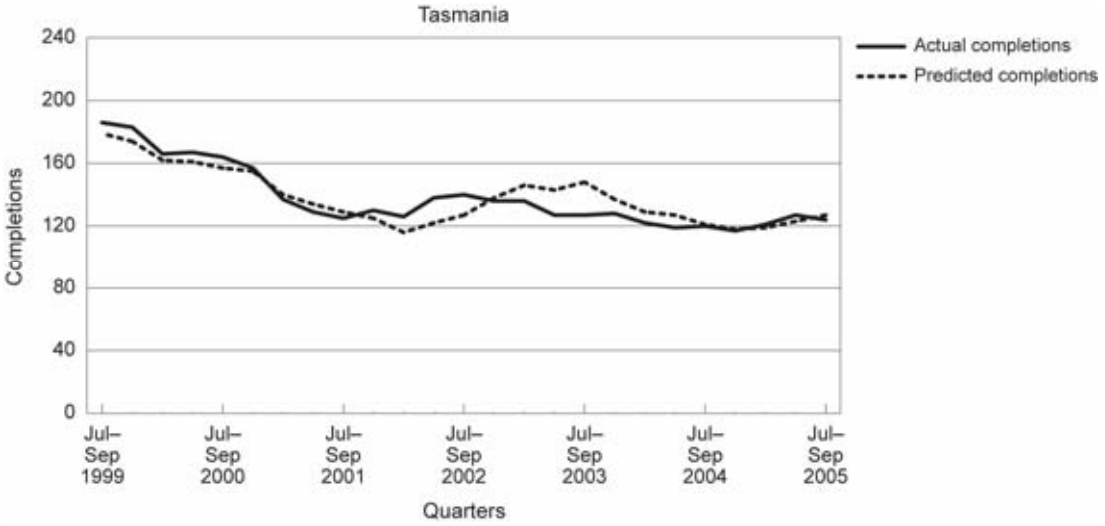

Victoria
Actual completions
Predicted completions
Completions
2000
1600
1200
800
400
0
Jul–Sep 1999
Jul–Sep 2000
Jul–Sep 2001
Jul–Sep 2002
Jul–Sep 2003
Jul–Sep 2004
Jul–Sep 2005
Quarters

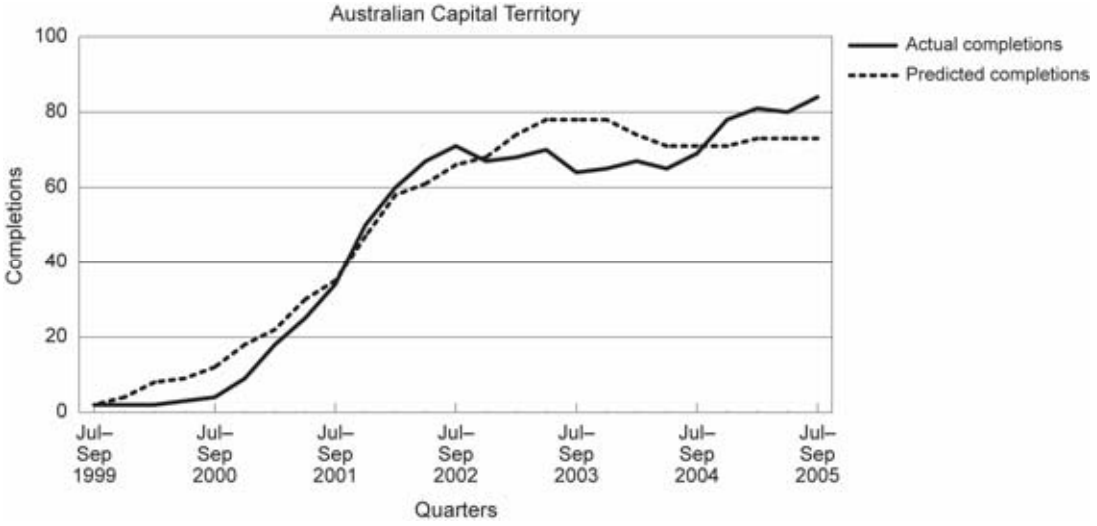

Queensland
Actual completions
Predicted completions
Completions
1500
1200
900
600
300
0
Jul–Sep 1999
Jul–Sep 2000
Jul–Sep 2001
Jul–Sep 2002
Jul–Sep 2003
Jul–Sep 2004
Jul–Sep 2005
Quarters


Western Australia
Actual completions
Predicted completions
Completions
800
700
600
500
400
300
200
100
0
Jul–Sep 1999
Jul–Sep 2000
Jul–Sep 2001
Jul–Sep 2002
Jul–Sep 2003
Jul–Sep 2004
Jul–Sep 2005
Quarters


South Australia
Actual completions
Predicted completions
Completions
600
500
400
300
200
100
0
Jul–Sep 1999
Jul–Sep 2000
Jul–Sep 2001
Jul–Sep 2002
Jul–Sep 2003
Jul–Sep 2004
Jul–Sep 2005
Quarters


Northern Territory
Actual completions
Predicted completions
Completions
75
60
45
30
15
0
Jul–Sep 1999
Jul–Sep 2000
Jul–Sep 2001
Jul–Sep 2002
Jul–Sep 2003
Jul–Sep 2004
Jul–Sep 2005
Quarters


Tasmania
Actual completions
Predicted completions
Completions
240
200
160
120
80
40
0
Jul–Sep 1999
Jul–Sep 2000
Jul–Sep 2001
Jul–Sep 2002
Jul–Sep 2003
Jul–Sep 2004
Jul–Sep 2005
Quarters



Source: Apprentice and Trainee Collection 46 (NCVER)

The model appears to fit the data pretty well, although there does appear to be a pattern by which the models under-predict in the earlier part of the period and over-predict more recently. We return to this observation later.

The coefficients of the models are shown in table 1. The table is best explained through an example. In Queensland, 20% of commencements in a quarter result in completion exactly 11 quarters later; 9% result in completion exactly 14 quarters later; and so on. The overall completion rate is the sum of all the coefficients, 85% in this case. This overall rate had a standard error of 1.37 percentage points, implying a 95% confidence interval of 85% plus or minus 1.96*1.37 percentage points. The derivation of the standard errors is shown in the appendix.

While the state coefficients are based on individual regression models, the Australian coefficients are obtained by summing the state coefficients, using appropriate rates reflecting their share of commencements. The derivation of the Australian completion rate is also shown in the appendix.

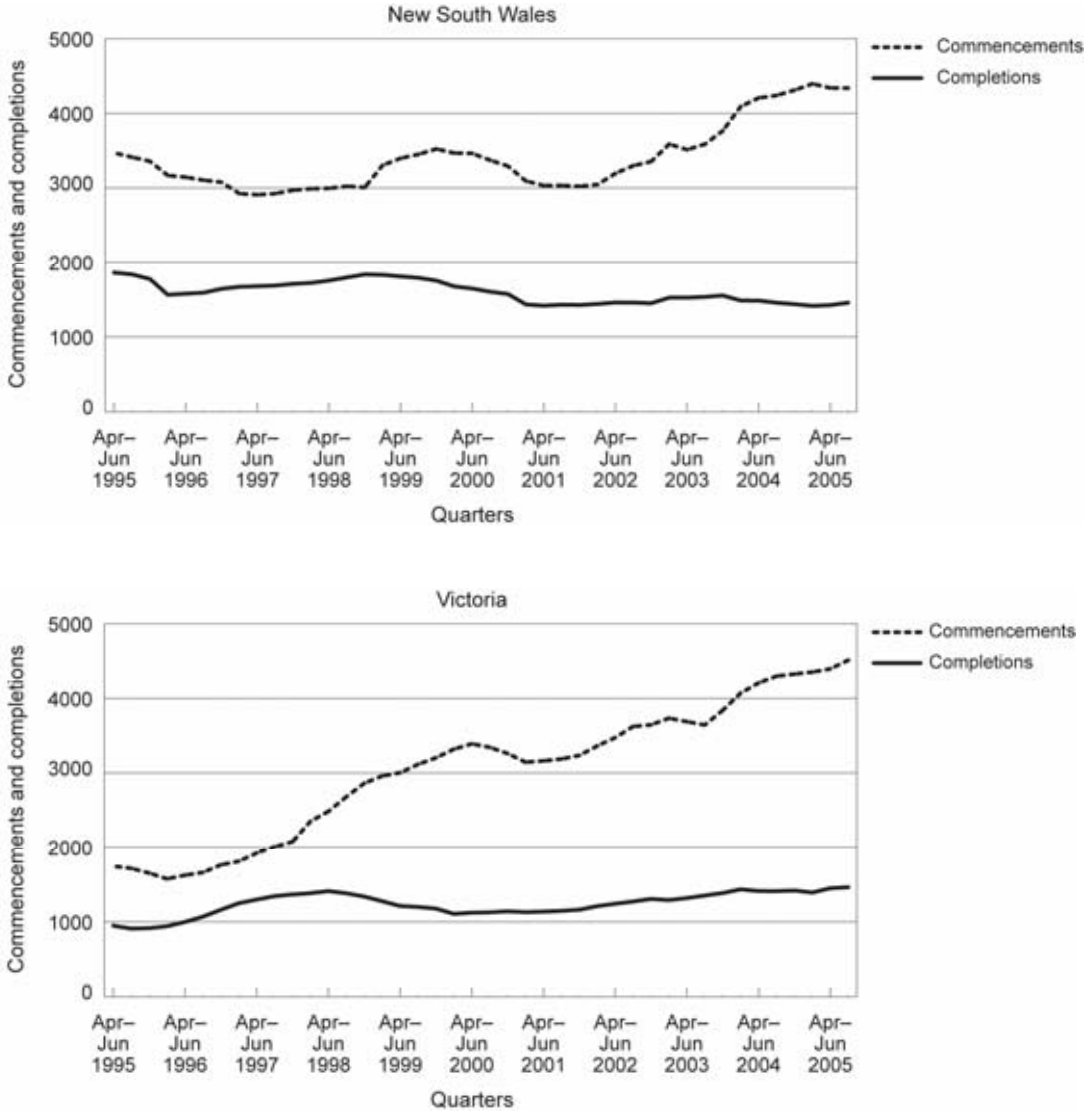
Table 1 Coefficients of the completion models for traditional apprentices, 1998–2005

	States								Australia
	NSW	Vic.	Qld	WA	SA	NT	Tas.	ACT	
Quarter 8		0.25						0.08	0.08
Quarter 9				0.06		0.18	0.05		0.01
Quarter 10				0.08	0.03				0.01
Quarter 11			0.20		0.03			0.12	0.03
Quarter 12				0.16	0.22	0.29			0.03
Quarter 13					0.03			0.12	0.00
Quarter 14			0.09				0.06	0.06	0.02
Quarter 15				0.06		0.34	0.11	0.15	0.01
Quarter 16	0.48	0.19	0.49	0.51	0.29		0.67	0.28	0.38
Quarter 17			0.07						0.01
Completion rates	0.48	0.44	0.85	0.87	0.60	0.81	0.89	0.80	0.58
Standard errors of completion rates	0.0084	0.0193	0.0137	0.0063	0.0107	0.0364	0.0187	0.0314	0.0071

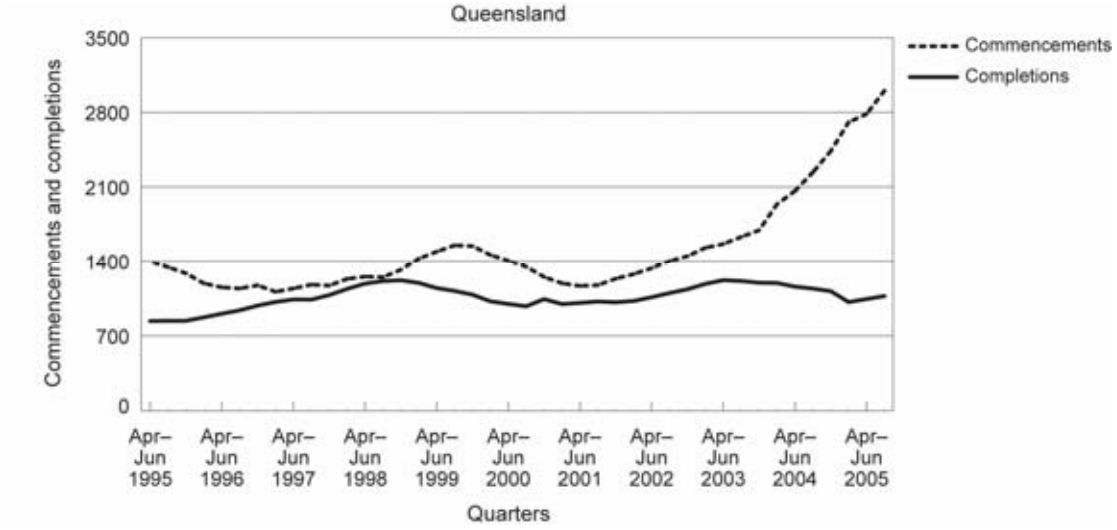
Source: Derived From Apprentice and Trainee Collection 46 (NCVER)

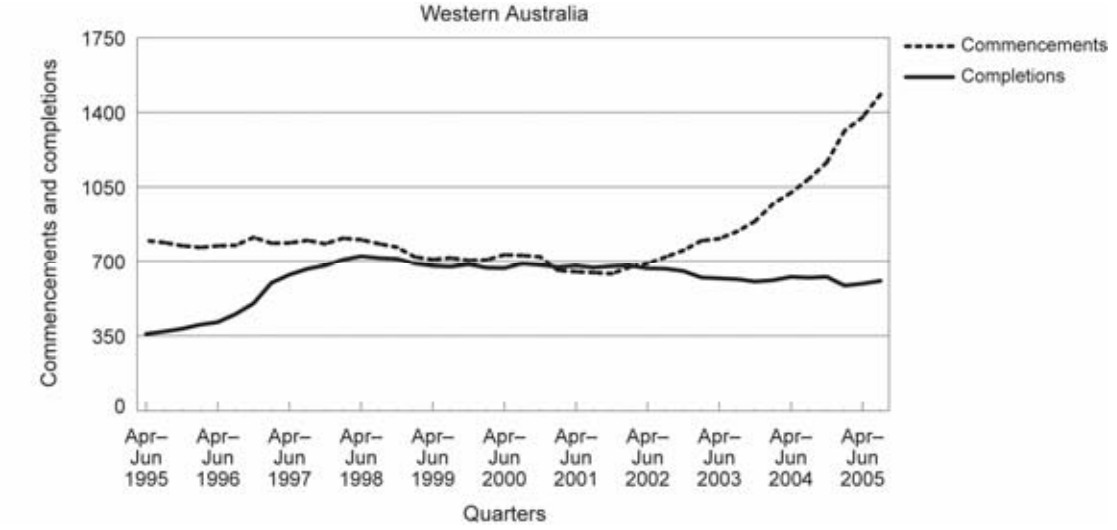
A number of points jump out from this table. First, the patterns of completion vary across states. For example, in New South Wales all apprentices complete exactly after 16 quarters, while in the Australian Capital Territory, completions occur from eight quarters to 16 quarters.[2] The second point is that the completion rates vary dramatically across states. In this context, it should be noted that the standard errors are very small; the differences between the states are not caused by statistical error. It is also worth looking at simple plots of commencements and completions for each state (figure 3). Casual inspection shows that the relationship between the two series is very different by state, and the time series models provide a reasonably precise measure of each of the relationships. It is beyond the scope of this paper to explain the differences across states and territories. Possible explanations include differences in legislation, industrial arrangements, administrative practices and labour market conditions.

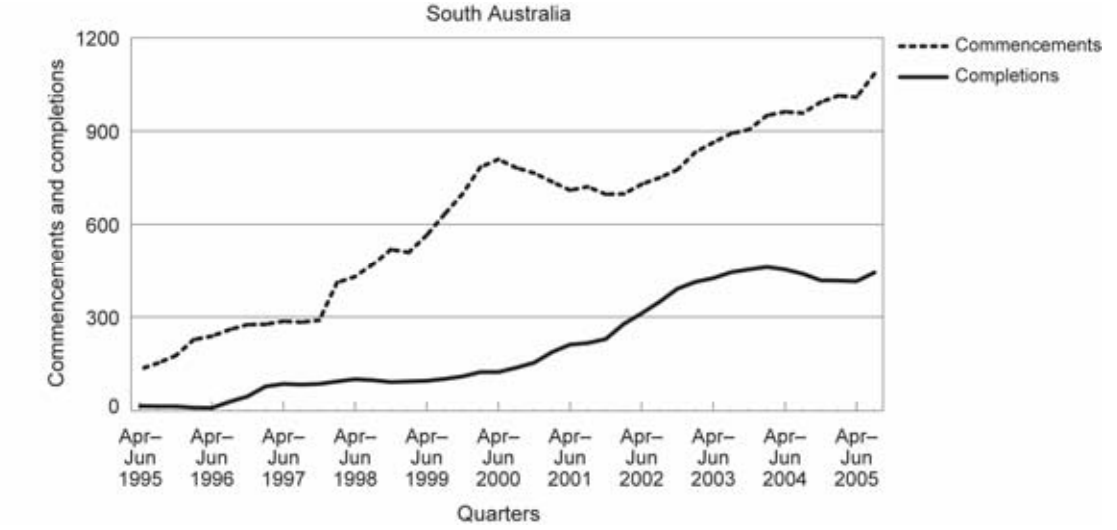
Figure 3 Commencements and completions for traditional apprenticeships (smoothed), states and territories, 1995–2005

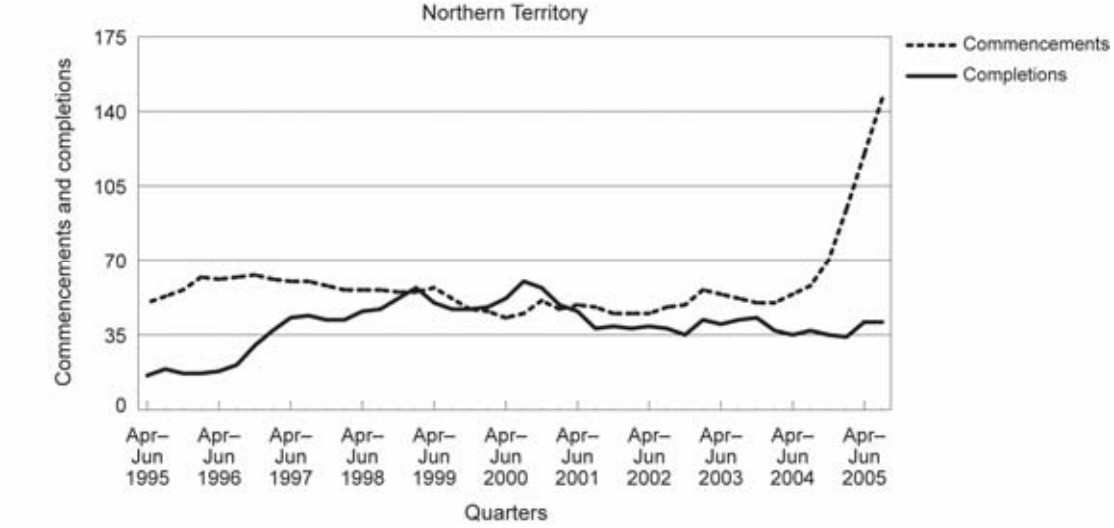


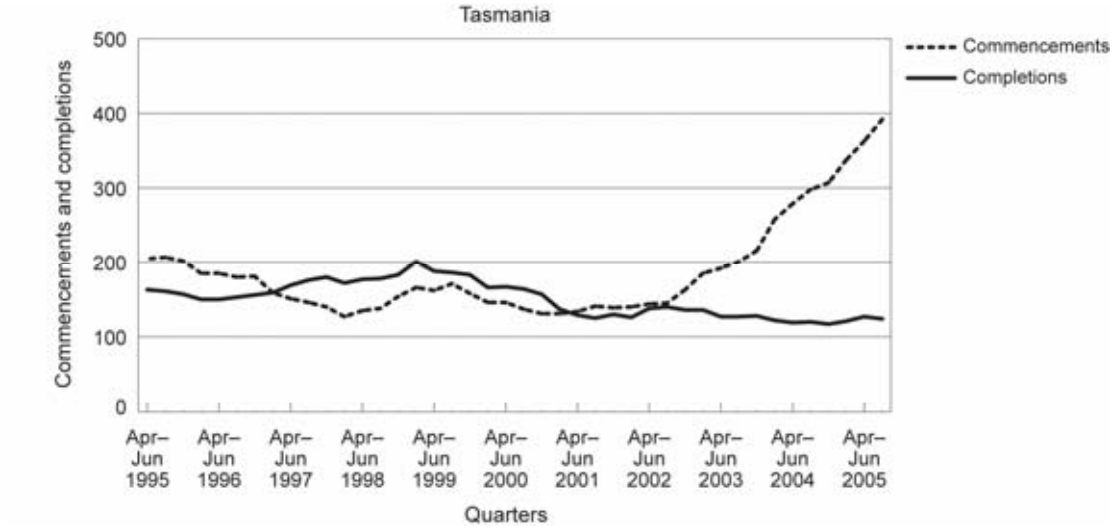
[2] The lags should not be taken literally; they fall out of the statistical modelling. No doubt some apprentices complete in other quarters, but the numbers are too small to affect the preferred lag structure.

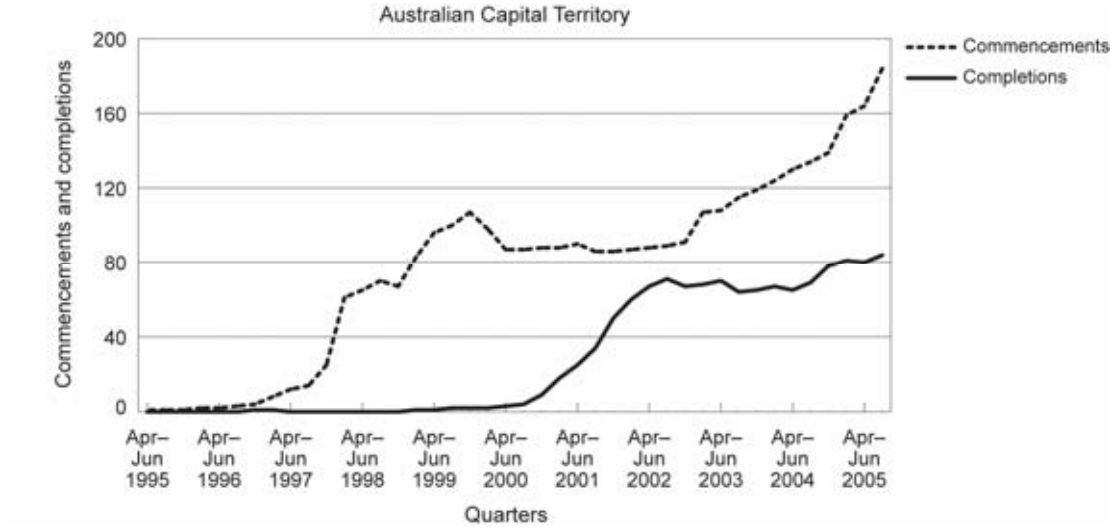

Queensland
Commencements and completions
3500
2800
2100
1400
700
0
Commencements
Completions
Apr–Jun 1995
Apr–Jun 1996
Apr–Jun 1997
Apr–Jun 1998
Apr–Jun 1999
Apr–Jun 2000
Apr–Jun 2001
Apr–Jun 2002
Apr–Jun 2003
Apr–Jun 2004
Apr–Jun 2005
Quarters


Western Australia
Commencements and completions
1750
1400
1050
700
350
0
Commencements
Completions
Apr–Jun 1995
Apr–Jun 1996
Apr–Jun 1997
Apr–Jun 1998
Apr–Jun 1999
Apr–Jun 2000
Apr–Jun 2001
Apr–Jun 2002
Apr–Jun 2003
Apr–Jun 2004
Apr–Jun 2005
Quarters


South Australia
Commencements and completions
1200
900
600
300
0
Commencements
Completions
Apr–Jun 1995
Apr–Jun 1996
Apr–Jun 1997
Apr–Jun 1998
Apr–Jun 1999
Apr–Jun 2000
Apr–Jun 2001
Apr–Jun 2002
Apr–Jun 2003
Apr–Jun 2004
Apr–Jun 2005
Quarters







Source: Apprentice and Trainee Collection 46 (NCVER)

Changes over time

We noted earlier that the models tended to under-predict at the beginning of the period and over-predict at the end. This indicates that the underlying relationship between commencements and completions has changed over the period (and the completion rate has changed). We take a simple approach to test this proposition by dividing the period into two and fitting separate models for each period. It is worth pointing out at this stage that we are fitting very simple statistical models aimed at quantifying the relationship between commencements and completions. We are not trying to explain what is driving the relationship. (For example, it is likely that the state of the labour market will affect completion rates.)

Table 2 presents the results. Clearly, there has been a decline in the completion rates of an appreciable magnitude in some states, for example, in New South Wales, Victoria, Tasmania and the Australian Capital Territory. By contrast, the rates in Queensland, Western Australia, South Australia and the Northern Territory have remained constant or increased a little. At the Australian level there has been a decline of some magnitude, from 64% to 57%. Again, the standard errors (see table 27 in the appendix) are relatively small, indicating that this decline is statistically significant.

Table 2 Completion rates of traditional apprenticeships, 1998–2002, 2002–05

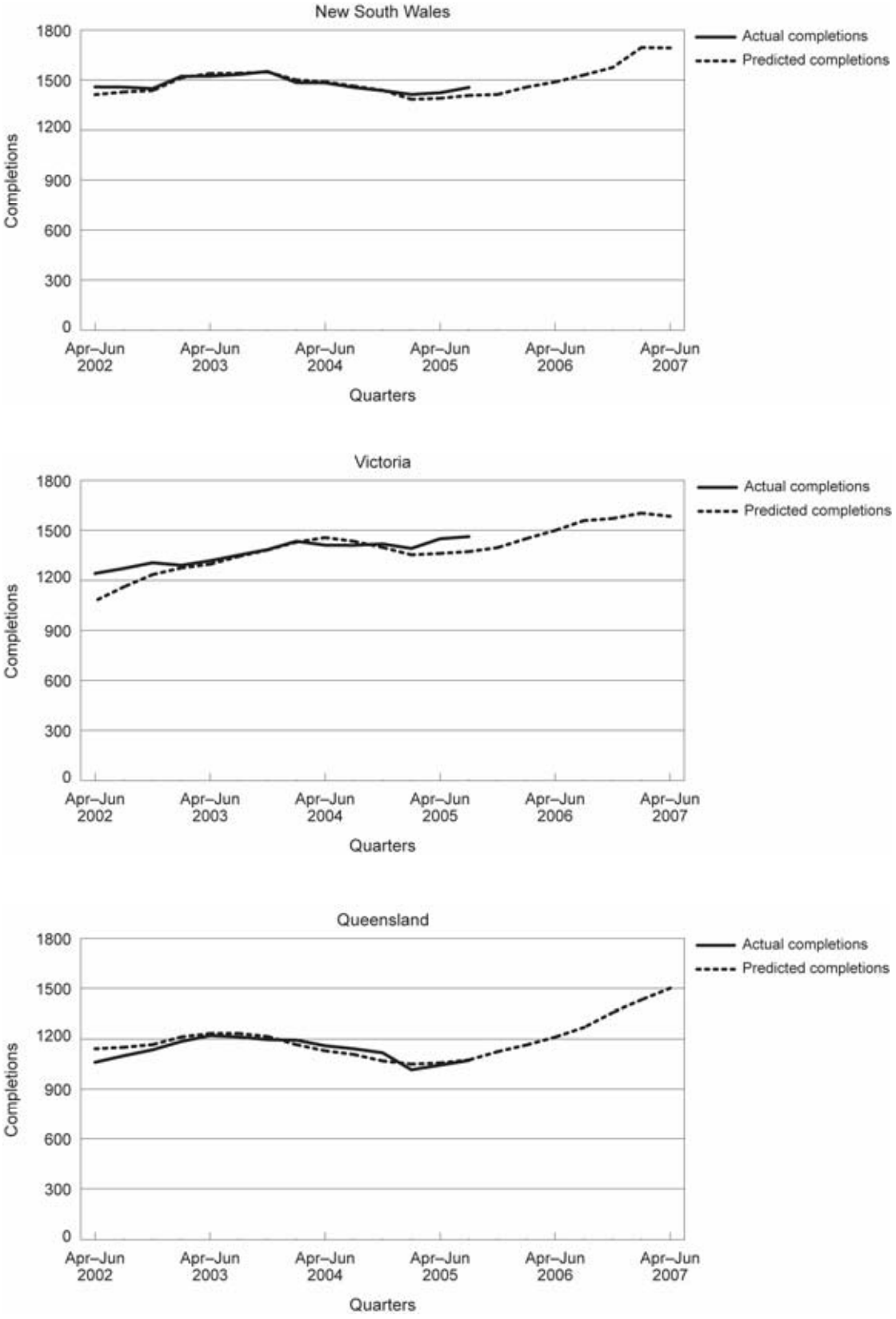
States	1998–2002	2002–05
New South Wales	0.52	0.45
Victoria	0.58	0.44
Queensland	0.84	0.85
Western Australia	0.87	0.87
South Australia	0.57	0.60
Northern Territory	0.79	0.80
Tasmania	0.92	0.86
Australian Capital Territory	0.88	0.78
Australia	**0.64**	**0.57**

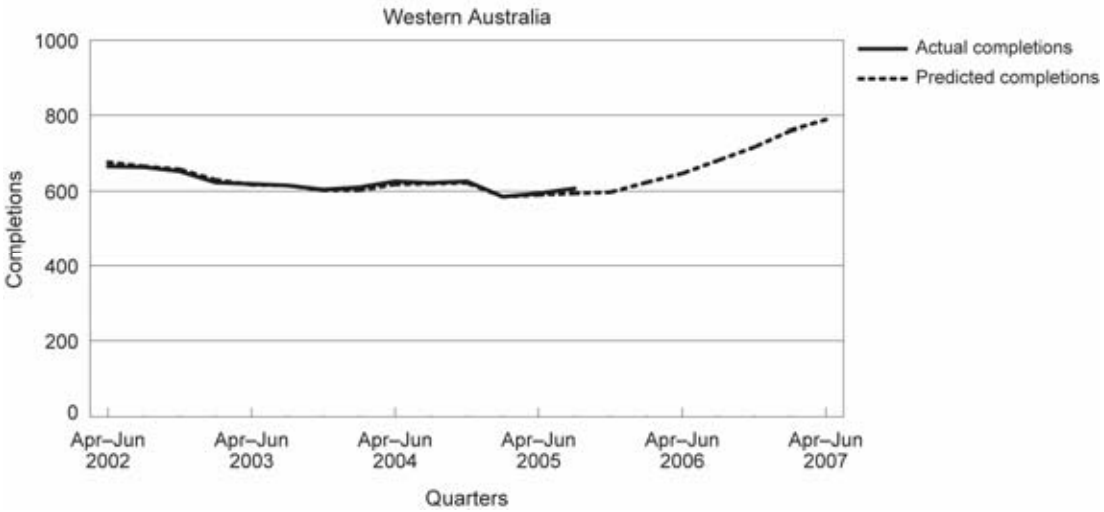
Source: Derived From Apprentice and Trainee Collection 46 (NCVER)

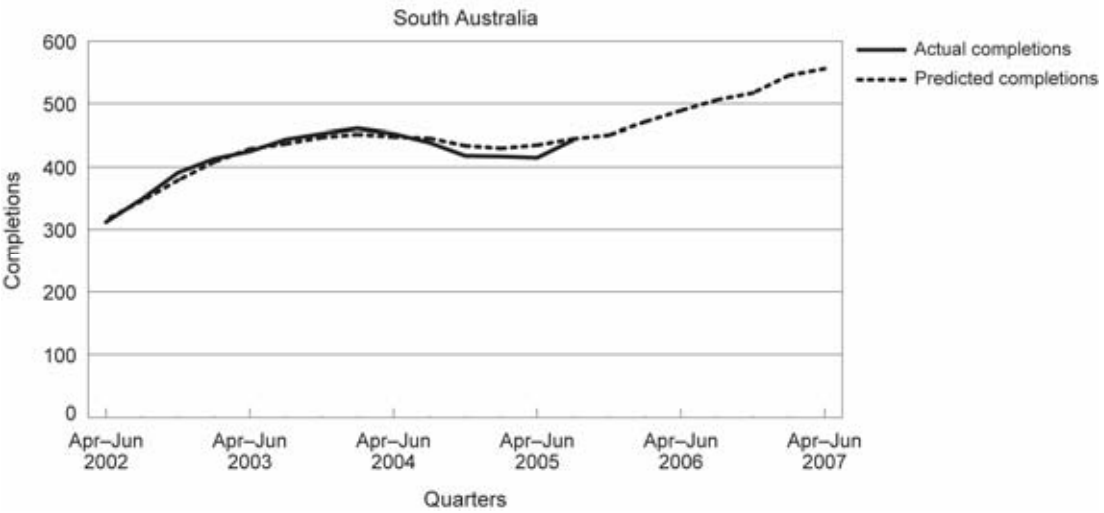
Predictions

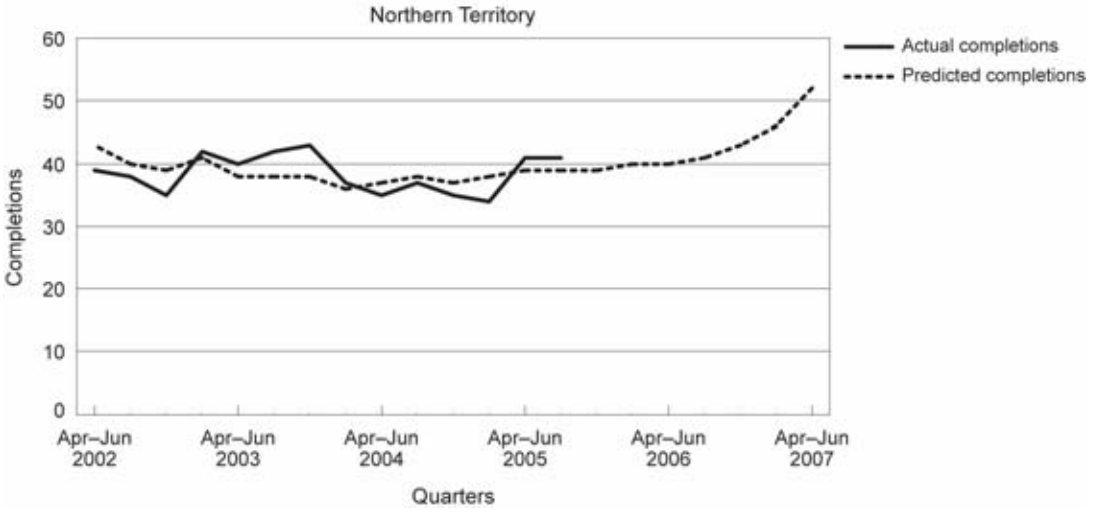
The starting point of the paper was the observation that, in recent years, commencements had increased, but completions had not. The models we have developed provide an understanding of the dynamics and allow us to predict what will happen to completions over coming quarters. Figure 4 provides these predictions, based on the models fitted to the second part of the period. It can be seen that in all states we expect to see an increase in traditional apprentice completions in coming quarters, as the apprentices begin to complete their apprenticeships.

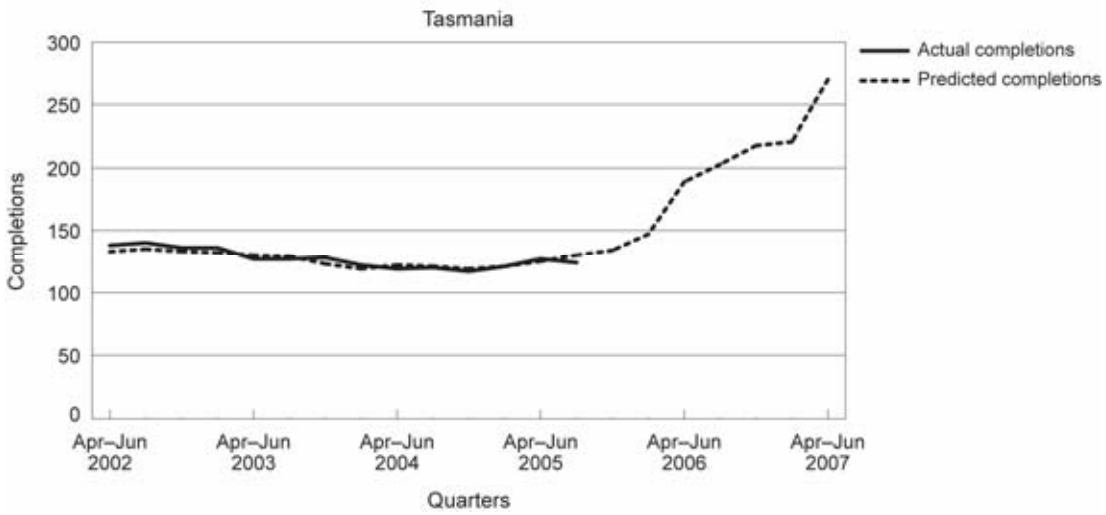
Figure 4 Completions for traditional apprenticeships, states and territories, and Australia, 2002–07

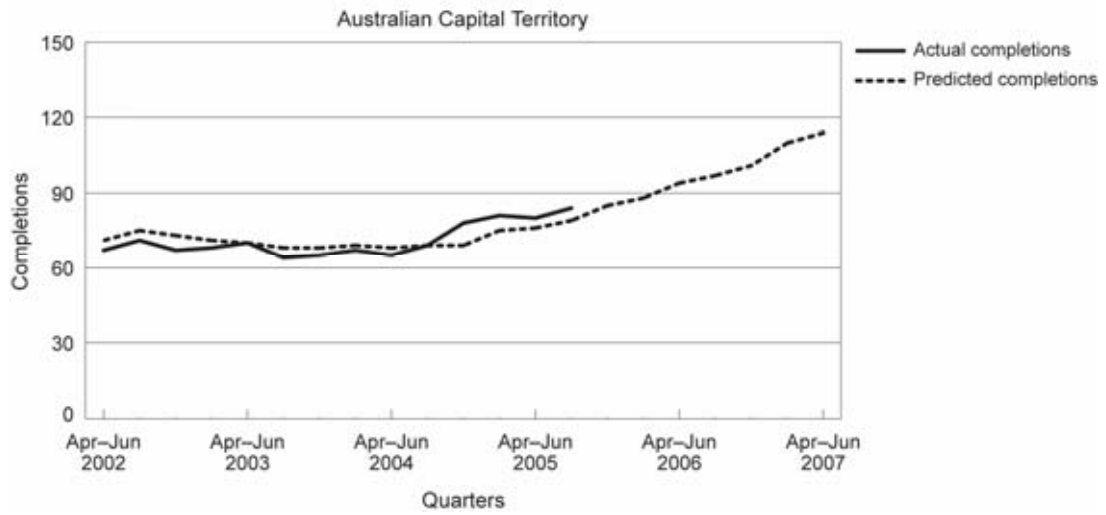


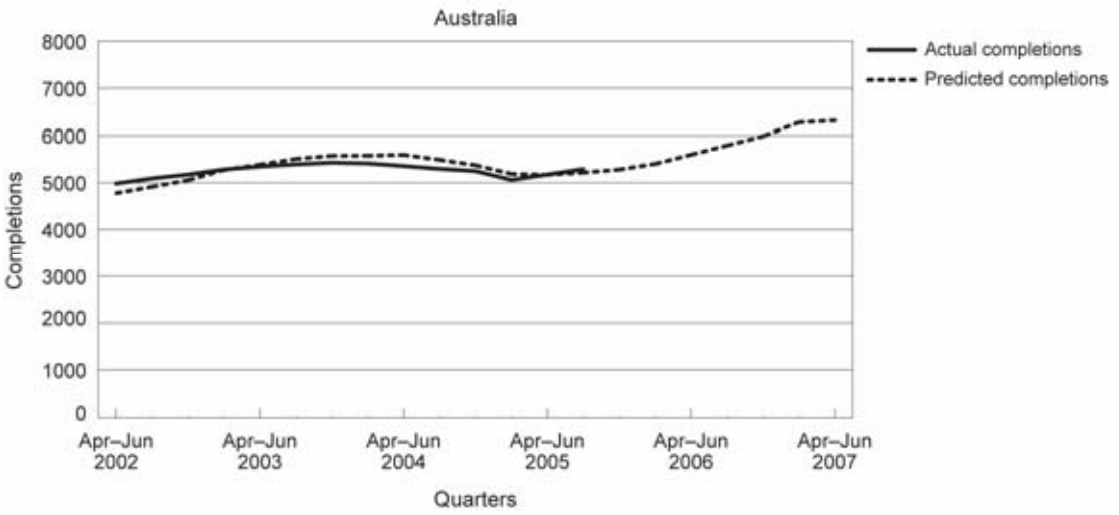

Western Australia
Actual completions
Predicted completions
Completions
1000
800
600
400
200
0
Apr–Jun 2002
Apr–Jun 2003
Apr–Jun 2004
Apr–Jun 2005
Apr–Jun 2006
Apr–Jun 2007
Quarters


South Australia
Actual completions
Predicted completions
Completions
600
500
400
300
200
100
0
Apr–Jun 2002
Apr–Jun 2003
Apr–Jun 2004
Apr–Jun 2005
Apr–Jun 2006
Apr–Jun 2007
Quarters


Northern Territory
Actual completions
Predicted completions
Completions
60
50
40
30
20
10
0
Apr–Jun 2002
Apr–Jun 2003
Apr–Jun 2004
Apr–Jun 2005
Apr–Jun 2006
Apr–Jun 2007
Quarters







Source: Derived From Apprentice and Trainee Collection 46 (NCVER)

Discussion

This short paper has looked at the statistical relationship between commencements and completions of contracts associated with traditional apprentices, with a view to obtaining a better understanding of the dynamics between the two variables. While our focus is on the dynamics, one output of our models is an estimate of the overall completion rate (by state and Australia-wide). However, it needs to be noted that this estimate is a little limited, in that it focuses on contracts of training rather than on individuals. Ball and John (2005) estimate that the completion rate of traditional apprenticeships increases by around six to ten percentage points (depending on which commencing cohort they consider) if we include completions that may have involved a change in employer. They also estimate that the completion rate for those who commence a traditional apprenticeship increases by 16 to 17 percentage points if we include completions that may involve a change in employer and a change in qualification. Ball and John also allowed for expired contracts, for which no completion is recorded, although a proportion does result in a completion.[3]

While our model does not allow for completions from expired contracts, our estimates of contract completion rates are a little higher than those of Ball and John: their estimate for the cohort commencing in 1999 was 52%, compared with our estimate of 57% for the period 2002–05.

The Ball and John study also indicated a decline in completion rates, with a drop in the single contract completion rate from 64.6% for the cohort commencing in 1995 to 51.6% for the cohort commencing in 1999. Again, this decline is consistent with the results of our modelling exercise, although the magnitude of the decline in Ball and John's work is somewhat larger than what we have found.

Conclusion

The focus of the paper was the dynamics of the relationship between commencements and completions for traditional apprenticeships, to enable us to understand what has been happening to completions in recent quarters. Our conclusion is that the primary reason for the lack of increase in the numbers of completions has been the lags between commencements and completions, although at the Australia-wide level there appears to have been a fall in the completion rate. We expect to see increases in the numbers of completions in coming quarters.

In the course of the modelling two other points of note also emerged. The first is that the lag structures vary quite dramatically across states. In New South Wales, according to the statistical model, all completions occur 16 quarters after commencement, no doubt related to a model in which traditional apprenticeships take four years. By contrast, early completion is common in the other states but occurring with different patterns. The second is that the implied overall completion rates vary across states and this variation is rather large. While the overall completion rate estimated for the period 2002–05 is 57%, individual state estimates vary from below 50% to over 80%.

References

Ball, K & John, D 2005, *Apprentice and trainee completion rates*, NCVER, Adelaide.

[3] Ball and John report that expired contracts were between 5% and 6% in 2001 (broadly corresponding to their 1999 cohort). They assumed that 45% of these would result in a completion. However, we do not have information on hand about the distribution of expired contracts across different types of apprenticeships and traineeships.

Appendix 1

Time series analysis

The appendix describes the simple statistical time series models we use for the time series analysis in the paper.

We use simple linear regression through the origin for each state for the time series analysis and fit separate models for each state. To reach the final model for each state, at first we drop the negative α coefficients. We re-run the regression until all negative α coefficients are dropped. Then, we drop the coefficients with t-value ≤ 1.50. (The coefficient with minimum t-value among these is dropped first, and the regression re-run until all α coefficients with t-value ≤ 1.50 are dropped.) The final models for each state have positive coefficients with t-values > 1.50.

The models fit completions in a particular quarter t on commencements lagged by up to 17 quarters. Then, the final completions rates are aggregated by each state's corresponding share to calculate national completion rates. The basic equation we use is:

$$completions_t = \sum_{i=8}^{17} \alpha_{t-i} commencements_{t-i}$$

Data

We use the quarterly time series data from the National Centre for Vocational Education Research (NCVER) Apprentice and Trainee Collection, September quarter 2005. The data cover the period September quarter 1994 to September quarter 2005.

For the regressions the data have been lagged and therefore begin at the December quarter 1998 and run until September quarter 2005. Also, to test the proposition that completion rates change over time, we divided the time period in two. The first time period is December quarter 1998 to March quarter 2002 and the second time period is June quarter 2002 to September quarter 2005.

Data for figure 2 is for the period 1999–2005 (September quarter 1999 to September quarter 2005). The period from 1998 to 1999 is not included because the completions are smoothed over four quarters and therefore there are no data observations over this period to be smoothed. Figure 4 presents the predicted completions to the June quarter 2007. Predicted completions for this figure are based on completion rates for the second time period.

Regression results

The following tables present the regression results for our initial models (time period December quarter 1998 to September quarter 2005) for each state.

Table 3 Regression results for New South Wales

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{16}$	0.48	0.008	57.60

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	1	9 363 3820	93 633 820	3 317.67	< .0001
Residual	27	762 014	28 223		
Total	**28**	**94 395 834**			

Table 4 Regression results for Victoria

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{8}$	0.25	0.074	3.33
$Commencements_{16}$	0.19	0.088	2.21

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	2	50 377 675	25 188 838	533.03	<.0001
Residual	26	1 228 656	47 256		
Total	**28**	**51 606 331**			

Table 5 Regression results for Queensland

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{11}$	0.20	0.023	8.65
$Commencements_{14}$	0.09	0.023	4.12
$Commencements_{16}$	0.49	0.022	22.06
$Commencements_{17}$	0.07	0.022	2.95

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	4	35 066 582	8 766 646	1 003.75	<.0001
Residual	24	209 613	8 733.855		
Total	**28**	**35 276 195**			

Table 6 Regression results for Western Australia

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.06	0.008	6.98
$Commencements_{10}$	0.08	0.008	9.28
$Commencements_{12}$	0.16	0.057	2.86
$Commencements_{15}$	0.06	0.008	8.39
$Commencements_{16}$	0.51	0.055	9.26

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	5	14 027 116	2 805 423	4 569.13	<.0001
Residual	23	14 122	613.995		
Total	**28**	**14 041 238**			

Table 7 Regression results for South Australia

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{10}$	0.03	0.015	2.13
$Commencements_{11}$	0.03	0.017	1.53
$Commencements_{12}$	0.22	0.038	5.72
$Commencements_{13}$	0.03	0.017	2.01
$Commencements_{16}$	0.29	0.040	7.32

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	5	3 476 800	695 360	808.84	<.0001
Residual	23	19 773	859.700		
Total	**28**	**3 496 573**			

Table 8 Regression results for Northern Territory

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.18	0.051	3.49
$Commencements_{12}$	0.29	0.050	5.75
$Commencements_{15}$	0.34	0.050	6.76

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	3	54 112	18 037	166.84	<.0001
Residual	25	2 702.758	108.110		
Total	**28**	**56 815**			

Table 9 Regression results for Tasmania

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.05	0.025	1.97
$Commencements_{14}$	0.06	0.024	2.33
$Commencements_{15}$	0.11	0.022	5.13
$Commencements_{16}$	0.67	0.022	30.95

ANOVA

	df	Sum of squares	Mean square	F	Pr > F
Regression	4	683 991	170 998	730.82	<.0001
Residual	24	5 615.519	233.980		
Total	**28**	**689 607**			

Table 10 Regression results for Australian Capital Territory

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{8}$	0.08	0.039	2.06
$Commencements_{11}$	0.12	0.062	1.89
$Commencements_{13}$	0.12	0.030	3.94
$Commencements_{14}$	0.06	0.030	2.09
$Commencements_{15}$	0.15	0.070	2.09
$Commencements_{16}$	0.28	0.051	5.42

ANOVA

	df	Sum of squares	Mean square	F	Pr > F
Regression	6	91 913	15 319	123.47	<.0001
Residual	22	2 729.468	124.067		
Total	**28**	**94 642**			

Regression results for time period, December quarter 1998 to March quarter 2002, for each state are as follows.

Table 11 Regression results for New South Wales

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{15}$	0.02	0.011	1.59
$Commencements_{16}$	0.50	0.011	47.09

ANOVA

	df	Sum of squares	Mean square	F	Pr > F
Regression	2	55 821 485	27 910 743	1 839.03	<.0001
Residual	12	182 123	15 177		
Total	**14**	**56 003 608**			

Table 12 Regression results for Victoria

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{16}$	0.58	0.025	23.38

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	1	23 360 590	23 360 590	546.85	<.0001
Residual	13	555 341	42 719		
Total	**14**	**23 915 931**			

Table 13 Regression results for Queensland

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{11}$	0.17	0.027	6.26
$Commencements_{14}$	0.09	0.033	2.63
$Commencements_{16}$	0.54	0.027	19.81
$Commencements_{17}$	0.05	0.030	1.53

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	4	17 137 816	4 284 454	588.29	<.0001
Residual	10	72 829	7 282.940		
Total	**14**	**17 210 645**			

Table 14 Regression results for Western Australia

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.05	0.012	4.48
$Commencements_{10}$	0.07	0.012	5.88
$Commencements_{12}$	0.28	0.090	3.10
$Commencements_{15}$	0.06	0.010	5.93
$Commencements_{16}$	0.41	0.086	4.72

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	5	8 425 384	1 685 077	2532.77	<.0001
Residual	9	5 987.797	665.311		
Total	**14**	**8 431 372**			

Table 15 Regression results for South Australia

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{11}$	0.05	0.017	2.80
$Commencements_{12}$	0.16	0.047	3.47
$Commencements_{16}$	0.36	0.057	6.42

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	3	723 950	241 317	429.57	<.0001
Residual	11	6 179.376	561.761		
Total	**14**	**730 129**			

Table 16 Regression results for Northern Territory

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{8}$	0.35	0.070	4.97
$Commencements_{15}$	0.44	0.067	6.65

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	2	32 562	16 281	107.44	<.0001
Residual	12	1 818.473	151.539		
Total	**14**	**34 380**			

Table 17 Regression results for Tasmania

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{11}$	0.14	0.022	6.37
$Commencements_{14}$	0.07	0.023	2.93
$Commencements_{16}$	0.71	0.018	39.34

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	3	456 066	152 022	1 126.53	<.0001
Residual	11	1 484.416	134.947		
Total	**14**	**457 550**			

Table 18 Regression results for Australian Capital Territory

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{12}$	0.16	0.013	12.52
$Commencements_{13}$	0.10	0.012	8.48
$Commencements_{14}$	0.06	0.012	5.04
$Commencements_{15}$	0.39	0.013	30.76
$Commencements_{16}$	0.17	0.022	7.87

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	5	18 832	3 766.480	1 145.130	<.0001
Residual	9	29.60207	3.289		
Total	**14**	**18 862**			

Regression results for time period, June quarter 2002 to September quarter 2005, are as follows.

Table 19 Regression results for New South Wales

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{12}$	0.16	0.082	1.99
$Commencements_{16}$	0.29	0.080	3.65

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	2	38 261 596	19 130 798	1 757.40	<.0001
Residual	12	130 630	10 886		
Total	**14**	**38 392 226**			

Table 20 Regression results for Victoria

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{15}$	0.04	0.016	2.76
$Commencements_{16}$	0.39	0.016	24.37

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	2	27 599 444	13 799 722	1 820.63	<.0001
Residual	12	90 956	7 579.660		
Total	**14**	**27 690 400**			

Table 21 Regression results for Queensland

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{11}$	0.24	0.032	7.33
$Commencements_{14}$	0.10	0.028	3.68
$Commencements_{16}$	0.43	0.030	14.09
$Commencements_{17}$	0.08	0.028	2.98

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	4	17 993 687	4 498 422	625.970	<.0001
Residual	10	71 863	7 186.283		
Total	**14**	**18 065 550**			

Table 22 Regression results for Western Australia

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.06	0.008	7.50
$Commencements_{10}$	0.09	0.008	11.45
$Commencements_{11}$	0.08	0.009	8.43
$Commencements_{16}$	0.64	0.009	73.69

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	4	5 607 168	1 401 792	5 195.700	<.0001
Residual	10	2 697.985	269.799		
Total	**14**	**5 609 866**			

Table 23 Regression results for South Australia

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.03	0.018	1.70
$Commencements_{12}$	0.32	0.055	5.83
$Commencements_{14}$	0.05	0.021	2.21
$Commencements_{16}$	0.20	0.055	3.69

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	4	2 757 112	689 278	738.600	<.0001
Residual	10	9 332.240	933.224		
Total	**14**	**2 766 444**			

Table 24 Regression results for Northern Territory

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.23	0.068	3.35
$Commencements_{12}$	0.27	0.079	3.39
$Commencements_{15}$	0.30	0.073	4.20

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	3	21 419	7 139.752	77.320	<.0001
Residual	11	1 015.743	92.340		
Total	**14**	**22 435**			

Table 25 Regression results for Tasmania

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{9}$	0.06	0.039	1.53
$Commencements_{11}$	0.16	0.048	3.34
$Commencements_{12}$	0.33	0.185	1.76
$Commencements_{16}$	0.32	0.176	1.81

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	4	229 749	57 437	248.830	<.0001
Residual	10	2 308.264	230.826		
Total	**14**	**232 057**			

Table 26 Regression results for Australian Capital Territory

	Coefficients		t-value
	Value	Standard errors	
$Commencements_{8}$	0.37	0.034	10.73
$Commencements_{11}$	0.27	0.038	7.12
$Commencements_{13}$	0.14	0.032	4.32

ANOVA					
	df	Sum of squares	Mean square	F	Pr > F
Regression	3	74 348	24 783	190.420	<.0001
Residual	11	1 431.595	130.145		
Total	**14**	**75 780**			

Completion rate: Australia

The overall completion rate for Australia, as shown in tables 1 and 2, is derived by assuming a steady state in which the share of commencements attributed to each state is constant.

Define C_i^{Aus} as the proportion of commencements for Australia that are completed after *i* quarters.

Denote S_n as the share of commencements for state *n* and α_i^n as the coefficient from the relevant model for state *n* and lag *i*.

Then $C_i^{Aus} = \sum_{n=1}^{8} S_n \alpha_i^n$

This gives the proportions completed for Australia from quarters 8 to 17 as in table 1.

The overall completion rate for Australia, as in tables 1 and 2, is:

$C^{Aus} = \sum_{i=8}^{17} C_i^{Aus}$

Note that C^{Aus} can also be written as $C^{Aus} = \sum_{n=1}^{8} S_n C_i^n$ where $C^n = \sum_{i=8}^{17} \alpha_i^n$

Standard errors

Standard errors for each state and Australia for all the three time periods are given in table 27.

Table 27 Standard errors, 1998–2005, 1998–2002, 2002–05

States	1998–2005	1998–2002	2002–05
New South Wales	0.0084	0.0094	0.0080
Victoria	0.0193	0.0250	0.0074
Queensland	0.0137	0.0190	0.0171
Western Australia	0.0063	0.0092	0.0063
South Australia	0.0107	0.0203	0.0121
Northern Territory	0.0364	0.0545	0.0534
Tasmania	0.0187	0.0187	0.0302
Australian Capital Territory	0.0314	0.0153	0.0332
Australia	**0.0071**	**0.0091**	**0.0089**

To calculate the standard errors for each state we used the following formula:

$SE(C^n) = SE(\sum_{i=8}^{17} \alpha_i)$

where α is the coefficient from relevant model for state *n,*

so $SE(C^n) = \sqrt{\left(\sum_i \operatorname{var} \alpha_i + \sum_{i \neq k} \operatorname{cov} \alpha_i \alpha_k\right)}$

The standard error for Australia is calculated as follows, noting that the various state estimates of completion rates are independent:

$SE(C^{Aus}) = \sqrt{\sum S_n^2 \operatorname{var} C^n}$

variances and covariances for the coefficients for all three time periods are shown in tables 28–51.

Time period December quarter 1998 to September quarter 2005

Table 28 Covariance-variance matrix for New South Wales

	Commencements16
Commencements16	0.000070

Table 29 Covariance-variance matrix for Victoria

	Commencements8	Commencements16
Commencements8	0.005513	-0.006425
Commencements16	-0.006425	0.007707

Table 30 Covariance-variance matrix for Queensland

	Commencements11	Commencements14	Commencements16	Commencements17
Commencements11	0.000520	-0.000172	-0.000134	-0.000175
Commencements14	-0.000172	0.000527	-0.000169	-0.000131
Commencements16	-0.000134	-0.000169	0.000493	-0.000143
Commencements17	-0.000175	-0.000131	-0.000143	0.000495

Table 31 Covariance-variance matrix for Western Australia

	Commencements 9	Commencements 10	Commencements 12	Commencements 15	Commencements 16
Commencements9	0.000068	-0.000021	-0.000067	-0.000015	0.000045
Commencements10	-0.000021	0.000069	-0.000091	-0.000019	0.000071
Commencements12	-0.000067	-0.000091	0.003282	0.000021	-0.003105
Commencements15	-0.000015	-0.000019	0.000021	0.000059	-0.000037
Commencements16	0.000045	0.000071	-0.003105	-0.000037	0.002997

Table 32 Covariance-variance matrix for South Australia

	Commencements 10	Commencements 11	Commencements 12	Commencements 13	Commencements 16
Commencements10	0.000230	-0.000072	-0.000105	-0.000059	0.000007
Commencements11	-0.000072	0.000273	-0.000084	-0.000106	0.000011
Commencements12	-0.000105	-0.000084	0.001437	-0.000049	-0.001349
Commencements13	-0.000059	-0.000106	-0.000049	0.000276	-0.000029
Commencements16	0.000007	0.000011	-0.001349	-0.000029	0.001572

Table 33 Covariance-variance matrix for Northern Territory

	Commencements9	Commencements12	Commencements15
Commencements9	0.002601	-0.001012	-0.001085
Commencements12	-0.001012	0.002528	-0.001075
Commencements15	-0.001085	-0.001075	0.002541

Table 34 Covariance-variance matrix for Tasmania

	Commencements9	Commencements14	Commencements15	Commencements16
Commencements9	0.000622	-0.000228	-0.000091	-0.000185
Commencements14	-0.000228	0.000595	-0.000167	-0.000089
Commencements15	-0.000091	-0.000167	0.000466	-0.000144
Commencements16	-0.000185	-0.000089	-0.000144	0.000473

Table 35 Covariance-variance matrix for Australian Capital Territory

	Commence-ments8	Commence-ments11	Commence-ments13	Commence-ments14	Commence-ments15	Commence-ments16
Commencements8	0.001536	-0.000649	-0.000100	-0.000078	0.000617	-0.001548
Commencements11	-0.000649	0.003799	-0.000138	-0.000047	-0.003774	0.000689
Commencements13	-0.000100	-0.000138	0.000890	-0.000250	-0.000052	-0.000153
Commencements14	-0.000078	-0.000047	-0.000250	0.000915	-0.000253	-0.000107
Commencements15	0.000617	-0.003774	-0.000052	-0.000253	0.004854	-0.000981
Commencements16	-0.001548	0.000689	-0.000153	-0.000107	-0.000981	0.002643

Time period December quarter 1998 to March quarter 2002

Table 36 Covariance-variance matrix for New South Wales

	Commencements15	Commencements16
Commencements15	0.000115	-0.000069
Commencements16	-0.000069	0.000113

Table 37 Covariance-variance matrix for Victoria

	Commencements16
Commencements16	0.000623

Table 38 Covariance-variance matrix for Queensland

	Commencements11	Commencements14	Commencements16	Commencements17
Commencements11	0.000749	-0.000302	-0.000180	-0.000266
Commencements14	-0.000302	0.001062	-0.000298	-0.000271
Commencements16	-0.000180	-0.000298	0.000744	-0.000224
Commencements17	-0.000266	-0.000271	-0.000224	0.000888

Table 39 Covariance-variance matrix for Western Australia

	Commencements 9	Commencements 10	Commencements 12	Commencements 15	Commencements 16
Commencements9	0.000144	-0.000048	-0.000104	-0.000025	0.000060
Commencements10	-0.000048	0.000139	-0.000048	-0.000033	0.000020
Commencements12	-0.000104	-0.000048	0.008029	-0.000051	-0.007664
Commencements15	-0.000025	-0.000033	-0.000051	0.000097	0.000022
Commencements16	0.000060	0.000020	-0.007664	0.000022	0.007416

Table 40 Covariance-variance matrix for South Australia

	Commencements11	Commencements12	Commencements16
Commencements11	0.000295	-0.000231	0.000040
Commencements12	-0.000231	0.002169	-0.002444
Commencements16	0.000040	-0.002444	0.003217

Table 41 Covariance-variance matrix for Northern Territory

	Commencements8	Commencements15
Commencements8	0.004929	-0.003208
Commencements15	-0.003208	0.004455

Table 42 Covariance-variance matrix for Tasmania

	Commencements11	Commencements14	Commencements16
Commencements11	0.000483	-0.000246	-0.000144
Commencements14	-0.000246	0.000548	-0.000113
Commencements16	-0.000144	-0.000113	0.000324

Table 43 Covariance-variance matrix for Australian Capital Territory

	Commencements 12	Commencements 13	Commencements 14	Commencements 15	Commencements 16
Commencements12	0.000166	-0.000042	-0.000021	0.000032	-0.000230
Commencements13	-0.000042	0.000146	-0.000044	-0.000029	0.000034
Commencements14	-0.000021	-0.000044	0.000153	-0.000047	0.000009
Commencements15	0.000032	-0.000029	-0.000047	0.000160	-0.000089
Commencements16	-0.000230	0.000034	0.000009	-0.000089	0.000462

Time period June quarter 2002 to September quarter 2005

Table 44 Covariance-variance matrix for New South Wales

	Commencements12	Commencements16
Commencements12	0.006700	-0.006507
Commencements16	-0.006507	0.006377

Table 45 Covariance-variance matrix for Victoria

	Commencements15	Commencements16
Commencements15	0.000258	-0.000232
Commencements16	-0.000232	0.000261

Table 46 Covariance-variance matrix for Queensland

	Commencements11	Commencements14	Commencements16	Commencements17
Commencements11	0.001046	-0.000305	-0.000269	-0.000337
Commencements14	-0.000305	0.000765	-0.000281	-0.000159
Commencements16	-0.000269	-0.000281	0.000915	-0.000257
Commencements17	-0.000337	-0.000159	-0.000257	0.000780

Table 47 Covariance-variance matrix for Western Australia

	Commencements9	Commencements10	Commencements11	Commencements16
Commencements9	0.000063	-0.000019	-0.000024	-0.000015
Commencements10	-0.000019	0.000064	-0.000023	-0.000018
Commencements11	-0.000024	-0.000023	0.000089	-0.000027
Commencements16	-0.000015	-0.000018	-0.000027	0.000076

Table 48 Covariance-variance matrix for South Australia

	Commencements9	Commencements12	Commencements14	Commencements16
Commencements9	0.000317	-0.000291	-0.000152	0.000153
Commencements12	-0.000291	0.002999	-0.000139	-0.002771
Commencements14	-0.000152	-0.000139	0.000438	-0.000113
Commencements16	0.000153	-0.002771	-0.000113	0.003015

Table 49 Covariance-variance matrix for Northern Territory

	Commencements9	Commencements12	Commencements15
Commencements9	0.004672	-0.002543	-0.001861
Commencements12	-0.002543	0.006308	-0.002290
Commencements15	-0.001861	-0.002290	0.005257

Table 50 Covariance-variance matrix for Tasmania

	Commencements9	Commencements11	Commencements12	Commencements16
Commencements9	0.001484	-0.000954	-0.003086	0.002426
Commencements11	-0.000954	0.002263	0.002805	-0.003541
Commencements12	-0.003086	0.002805	0.034291	-0.031709
Commencements16	0.002426	-0.003541	-0.031709	0.030993

Table 51 Covariance-variance matrix for Australian Capital Territory

	Commencements8	Commencements11	Commencements13
Commencements8	0.001173	-0.000498	-0.000348
Commencements11	-0.000498	0.001475	-0.000451
Commencements13	-0.000348	-0.000451	0.001044