FORECASTING THE DEMAND FOR TERTIARY EDUCATION USING ECONOMETRIC AND MARKOVIAN MODELS.*

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ABSTRACT

In this paper a model for the demand for tertiary education in the state of Victoria by qualified students leaving secondary school is developed and estimated. The objective of obtaining short-term forecasts is hampered by projection difficulties associated with one of the main independent variables, the eligibles (i.e., the pool of potential tertiary students). In order to overcome these difficulties an absorbing markov chain incorporating changing transition proportions is derived and applied. This markov model, coupled with more conventionally obtained projections of the remaining independent variables, is then used by the demand model to obtain the required forecasts.

INTRODUCTION TO THE PROBLEM AND SOLUTION METHODOLOGY

Any planning exercise undertaken by government concerning the tertiary education sector, requires as input, an appropriate forecast of the demand for this public good.

In Australia, few if any studies have been undertaken on the demand for tertiary education, contrary to the situation in the United Sates and Canada (see for example the work by Campbell and Siegel (1967), Handa and Skolnik (1975) and Pissarides (1981)). Typical of most studies mentioned above is the level of aggregation at which estimation takes place and the measure of demand used. The smallest level of aggregation used is the undergraduate and graduate categories at colleges or universities. These categories are far from homogeneous with respect to the sources of demand. High levels of aggregation usually lead to the elimination of individual trends and patterns of each of these sources, thereby reducing the amount of information and interpretation obtainable.

The usual measure of demand is the enrolments in the first, second, third and fourth years, If this measure is used, the current year's new demand and the current year's continuing demand are treated identically. This implies that the same determinants of demand in the same time periods are applicable to the new and continuing categories in exactly the same way. The use of distributed lags, as used by Galper and Dunn (1969), does not satisfactorily overcome this problem. Thus, even where studies have taken place, they are not necessarily sufficiently accurate or revealing enough for detailed planning purposes.

These demand models also make the assumption that there exists and operates a free (at least a non-excess demand) market for tertiary education. This implies that market forces primarily determine the demand and supply for tertiary education.

In Australia, demand models as discussed above have not, until now, been undertaken due to the lack of adequate data and a belief that the tertiary education market exhibited excess demand. The establishment of the necessary data for 1971 to 1981 inclusive, and the demonstration of substantial support for the operation of a market in which demand does not exceed supply in Victoria, led to a demand model being formulated and estimated. The demand for tertiary education (excluding Technical and Further Education) as measured by commencing enrolments (i.e., new enrolments) is split into three divisions, Colleges of Advanced Education-General(CAEGS's), Colleges of Advanced Education-Primarily Teacher Training (CAET's) and Universities. The sum of all these divisions forms the aggregate demand for which results are presented in this article. Analysis of full and part-time as well as total demand (i.e., full plus part-time) was undertaken for the aggregate demand.

The demand model arrived at in this paper derives its origin from the theory espoused by Blaug (1976) with added insights by Handa and Skolnik (1975), and is thus an econometric model. However, the main purpose in arriving at such a demand model is for forecasting demand and as such, there exists the need for the independent variables to be in turn forecast. This latter point was somewhat problematic for one of the independent variables and is discussed later in this papar.

The market chosen for examination was that of the successful higher school certificate candidates because of the availability of some detailed Statistics relating to the eligibles and its overall numerical dominance in Victoria (over 60% of all undergraduate commencing students).

The methodology of approach to determining demand forecasts for this market is as follows:-

a) In order to determine the main causes of changes in demand for tertiary education (government policy included), determine a demand model;

b) In order to obtain medium and short-term forecasts for the demand for tertiary education, obtain forecasts of the independent variables (in one case using a markovian model);

c) by linking a) and b), obtain the estimates (with or without the appropriate confidence limits).

THE DEMAND FOR TERTIARY EDUCATION - ITS MODELLING AND ESTIMATION

There are three classes of demand in the market used in this study: Previous Year (Lag 1), One Year Ago (Lag 2) and More Than One Year Ago (Lag 3). As implied, the Previous Year class of demand relates to the High School Certificate (HSC) candidates who, after passing the exams in November-December the previous year, enrol in a course of tertiary study in the current academic year. Thus the three classes of demand relate to the lag between qualifying to undertake tertiary education and actually demanding it. These three lags are interdependent, i.e., the Lag 1 demand in Year (t) will affect the demand for Lag 2 (t + 1), which in turn will have a direct bearing on the Lag 3 demand in year (t + 2). The largest (numerical) class of demand is Lag 1 and this article is restricted to consideration of this lag.

The assumption that the HSC 'market' has no excess demand is found by Nicholls (1984a) have adequate support.

The demand model is :

$$DA_t = f(TF_t, E_t, RHDY_t, YU_{t-1}) \qquad (1)$$

where f is a linear function; DA_t is the aggregate demand for tertiary education in academic year t (as at 30th April, the census date) by successful HSC candidates who qualified the previous year, TF_t is the government policy (tuition fees) variable; E_t is the number of eligibles i.e., the number of successful HSC candidates who, having just qualified, may demand tertiary education in the immediately succeeding academic year, $RHDY_t$ is the real household disposable income per capita for Victoria (a source of finance variable); YU_{t-1} is the youth unemployment rate (calendar year) lagged one year. The demand relationship postulated in (I) above is estimated for total, full and part-time demand categories.

Note also that the model includes youth unemployment rates (for 15-19 year olds) lagged one year. This lag is to ensure that the appropriate youth unemployment rate is matched with the period when it is postulated that potential tertiary students evaluate their future. It is suggested that youth unemployment might alter the appropriate opportunity costs of tertiary education, and thus be an important indirect variable in determining demand. This youth unemployment effect has been discussed in detail by Nicholls (1984a), (1984b).

Omitted from the list of possible independent explanatory variables were TEAS (Tertiary Education Assistance Scheme, now called AUSTUDY) and real unemployment benefits. TEAS was excluded due to the incompatibility and incompleteness of data available while real unemployment benefits were found (as was suggested by Merilees (1980)) to be statistically insignificant.

The results of the estimation of (1) above for total, full and part-time categories is as summarised in Table 1 below:

TABLE 1

Estimated Coefficients for Total, Full and Part-Time HSC Demand Function[b]

Category of Demand	Variable							
	CONSTANT	TF_t	E_t	RHDY	YU_{t-1}	$F^{(b)}$	$\bar{R}^2$	$\hat{\rho}$
Total[a]	-7543.66 (-4.4)" (c)	-525.07 (2.48)***	0.675 (11.67)*	5.80 (6.06)	-191.11 (-25.98)*	69.17*	0.995	-.751
Full-Time[a]	-7203.42 (-4.31)*	-525.86 (-2.55)**	0.658 (11.76)*	5.30 (5.68)*	-170.60	71.71*	0.995	-.75
Part-Time	68.62 (0.084)	-52.58 (-0.52)	0.038 (1.03)	0.106 (0.23)	-19.45 (3.61)**	4.17***	0.558	-.09

(a) First order auto-correlation existed in these (the total and full-time) demand model and was removed using the two-step full transform method (see Harvey, (1981)), whereas the part-time category did not. Consequently, the sum of full and part-time estimated coefficients of the variable do not sum exactly to the total values.

(b) Obtained from OLS results.

(c) *, **, *** indicates significance at the 1%, 5% and 10% levels respectively using a two-tail 't' test (t values in brackets).

The results in Table 1 above did not suffer from multicollinearity and the magnitudes and signs of the coefficients and their elasticities of demand (for income and eligibles) were in accordance with prior expectations and generally agreed with overseas studies.

The highly significant negative effect of youth unemployment on the demand for tertiary education lends credence to the suggestion that over the period under consideration, the discounting effect of youth unemployment on future expected returns to, and opportunity costs of, tertiary education has to lead to a negative <u>net</u> discounted benefit (at least as perceived by potential students). Psacharopoulos (1980) lends support inasmuch as the future returns to tertiary education in Europe and the United States have been found to be marginal at best (on average).

It is also obvious from Table 1 above that there are factors at work other than those included in the case of the part-time demand equation. Further investigation was not warranted as the part-time demand was only around 6% of the total.

Additionally, the relatively small impact of tuition fees on demand for tertiary education on total (around 5% of the average eligibles) has some implications, at least in the political arena. The fees impact would appear to be consistent with the findings of Radner and Miller (1970), but care should be taken in interpreting the results from dummy variables.

ESTABLISHING FORECASTS FOR THE FACTORS AFFECTING THE DEMAND FOR TERTIARY EDUCATION

The establishment of forecasts of the independent variables proved, in the case of eligibles, to be a very complex process. The eligibles are a direct product of the secondary school system (government schools and non-government schools) which is influenced to a large extent by population factors. The numbers of potential tertiary students emanating from the secondary system is not as easily predicted (and forecast) as one would imagine. Below is detailed the process of modelling and forecasting eligibles, followed by the forecasting of income and youth unemployment variables.

Forecasting Eligibles

The process by which secondary school students move through the system can be depicted as in Figure 1 below. It is suggested that the process is essentially the same for government and non-government schools, with the difference being reflected in the retention rates. Movements between these two systems at the secondary level is assumed (with good reason) to be minimal.

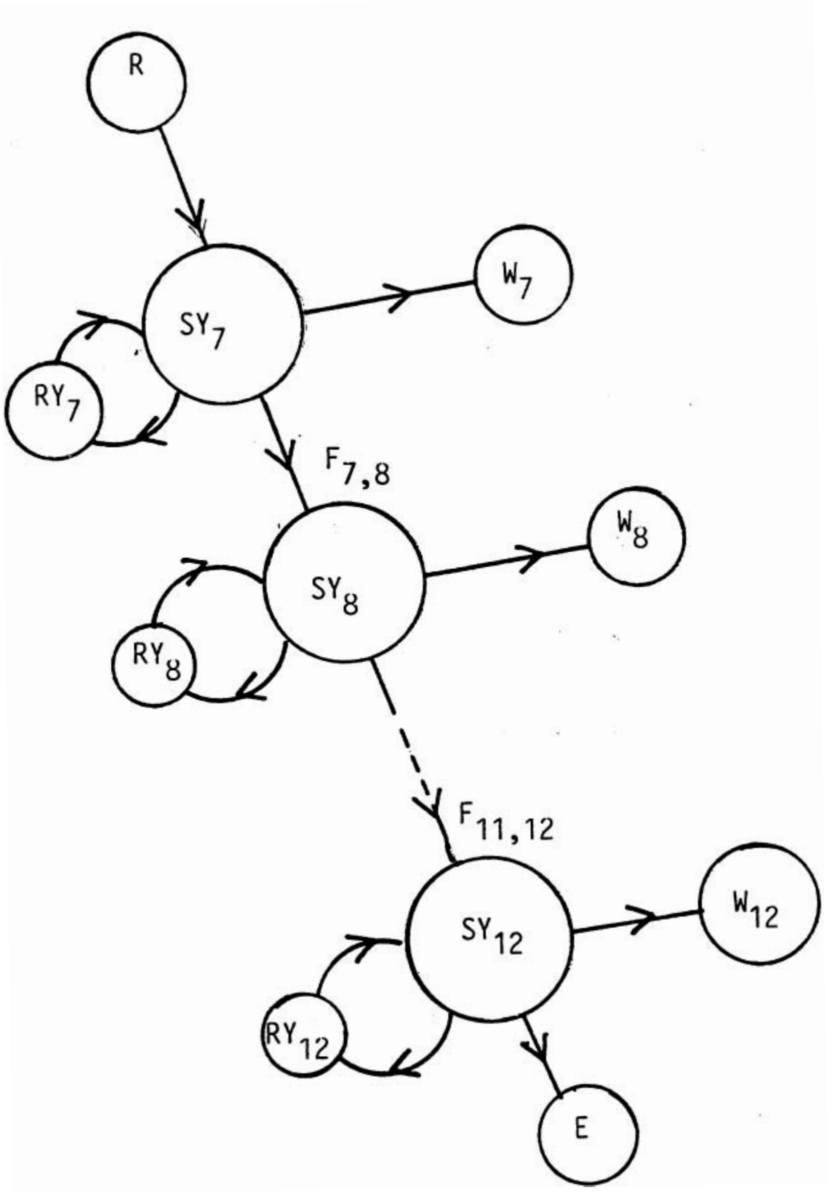

Figure 1 The Flow of Students Through the Secondary School Systems. Here, R represents recruitment into the system, E exit from the system, RY_i the repeating number of students in Year i, SY_i the stocks of students in Year i, $F_{i,j}$ the flow of students 'promoted' from Year i. Note the census date was 30 August each year and that Year 12 of the School System is equivalent Year 6 of the Secondary School System.

Figure 2 below then considers the process of exiting from the system for Year 12 students, indicating the eventual pool of potential tertiary students immediately available for the next academic year.

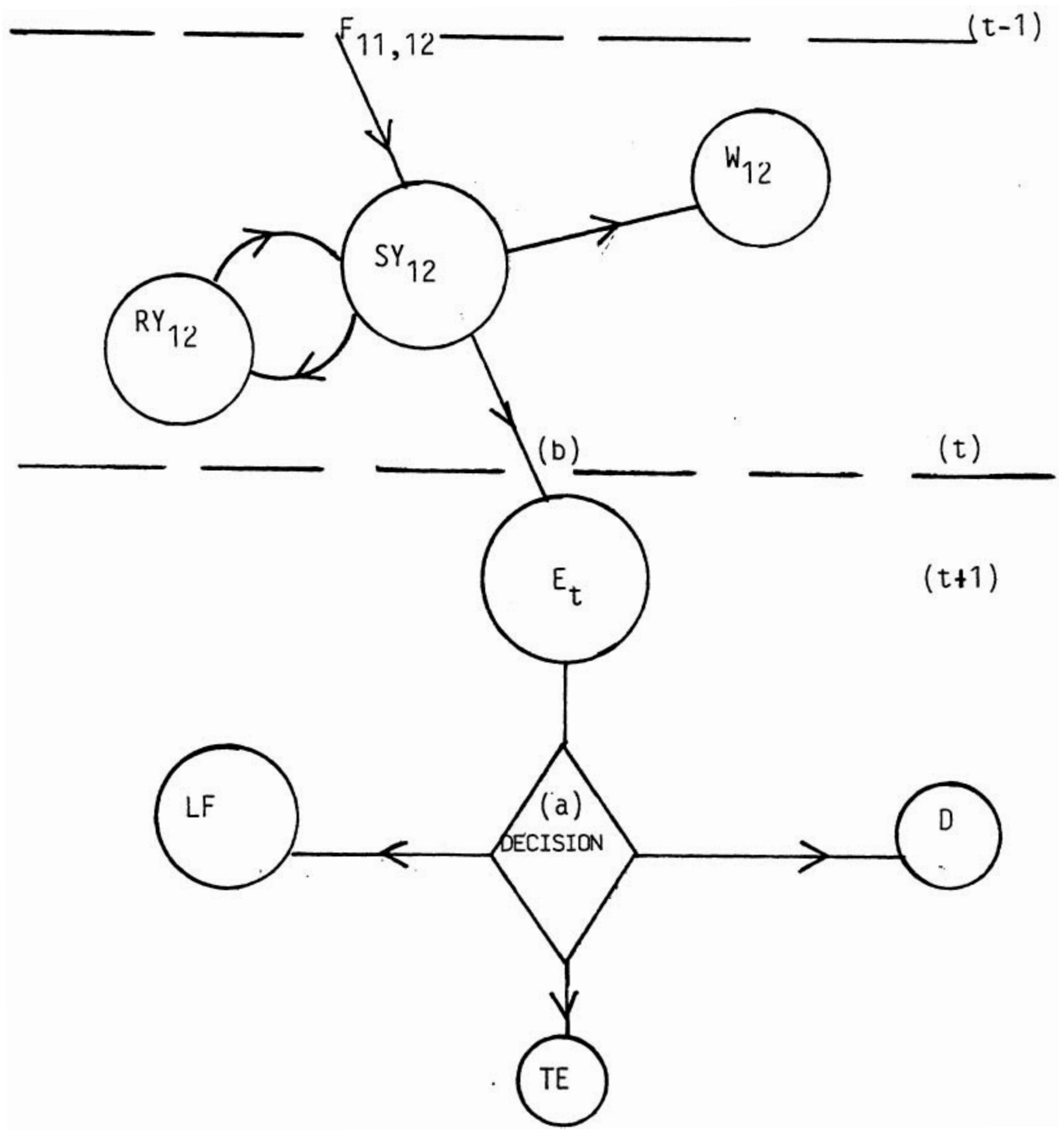

Figure 2 Simplified Schematic of Eligibles and Decision Paths

(a) This flow is successful students; i.e. those who have passed the Higher School Certificate (now called Victorian Certificate of Education.).

(b) This decision process is often considered by students in earlier years, but it is suggested that decisions are finally made at this point.

LF is labour force, TE is tertiary education and D is deferred tertiary education entry (official).

As is obvious from Figures 1 and 2 above, students (successful in secondary Year 5) flow into secondary Year 6 and coupled with the Repeating students (RY_6) less the wastage (W_6) yield the stock of students in Year 6 (SY_6) as at 30 August. These students if successful may then choose to undertake tertiary education immediately or in the future (deferred). Alternatively, they may join the labour force.

The modelling procedure normally used for educational systems by Johnstone and Philp (1973), Carn (1973) and Reeves (1977) has resulted in 'successful' applications to Primary School systems, where transition proportions are by definition constant (due to compulsory schooling). However, with changing transition proportions (as was found to exist in the post compulsory years of the Victorian Secondary School System) the traditional absorbing markov chain is inapplicable. Stone (1972) postulated a model that would allow for changing transition proportions, but did not expand beyond this suggestion.

Below is such an absorbing markov chain model, developed by Nicholls (1982) that will be applied to the government and non-government secondary school system (for males and females respectively). These categories are necessary to account for the inherent differences in behaviour of each.

The normal markov model is:

$$\bar{n}_j(t+1) = \sum_{i=1}^{r} n_i(t)q_{ij} + R(t+1)p_{oj} \qquad j=1,\ldots r \quad t=1,2,3,\ldots \quad (2)$$

where:

$\bar{n}_j(t+1)$ is the expected number of students in state j at time (t+1). In Victoria, the Secondary System contains six years school, Year 7 to School Year 12 (and state j) refer to secondary school Year j.

$n_i(t)$ is the expected number of students in state i at time t. If one period ahead projection is being used incorporating existing data in order to test the problem, $n_i(t)$ would be actual data (not the current year's estimate) and would be designated as $n_i(t)$.

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1. That is secondary years 4, 5 and 6 or generally speaking when students have turned fifteen.

q_{ij} is the transition probability of going from a non-absorbing state i to a non-absorbing state j in one transition, i.e. repeat and promotion probabilities.

$R(t + 1)$ is the total number of recruits injected into the system in time $(t + 1)$, i.e. an estimate in most models.

p_{oj} is the proportion (probability) of $R(T + 1)$ that enters state j in year $(t + 1)$. For the Victorian model, recruitment is confined to Year 7 only, thus $P_{o1} = 1.00$ and $p_{oj} = 0$ for $j = 2,\ldots,6$.

However, because one of the essential markovian assumptions has been violated (i.e. $q_{ij,t} = q_{ij,t+1}$ etc)

the new model is (in matrix terms):

$$\bar{n}(t) = n(0) \prod_{h=o}^{t} Q(h) + \sum_{\tau=o}^{t-1} \{(\prod_{h=o}^{\tau} Q(h)) (R(t-\tau))\}P_o \tag{3}$$

where

$$Q(t) = \sum_{l=1}^{s} (Q_l C_l(t)), \quad 1 \leq s \leq (2r-1) \tag{4}$$

where s refers to the number of non-zero diagonals in the $Q(t)$ matrix. For the Victorian models, s = 2, corresponding to the main and super diagonal containing the repeat and promotion rates respectively.

Then for l= 1, the components of equation (8) are as follows:

$$\underset{(r\times r)}{Q_1} = \begin{bmatrix} *q_{11,1} & & & 0 \\ & *q_{22,1} & & \\ & & \ddots & \\ 0 & & & *q_{rr,1} \end{bmatrix} \quad (5)^2 \qquad \underset{(r\times r)}{C_1(t)} = \begin{bmatrix} C_{11,1}(t) & & & 0 \\ & \ddots & & \\ & & \ddots & \\ 0 & & & C_{rr,1}(t) \end{bmatrix} \quad (6)$$

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2. The functional forms for $q_{ij,t}$ are:

$$q_{ij,t} = *q_{ij}C_{ij}$$
$$q_{ij,t} = *q_{ij}t^{C_{ij}}$$
$$q_{ij,t} = q_{ij}$$

where the average is primarily associated with promotion or repeat rates which are relatively constant or where no identifiable pattern exists in the changes.

and when $l = 2$

$$\underset{(r \times r)}{Q_2} = \begin{bmatrix} 0{*}q_{12,2} & & & \\ & 0{*}q_{23,2} & & 0 \\ 0 & & \ddots & {*}q_{(r-1)r,2} \\ & & 0 & \end{bmatrix} \; ; \quad (7) \qquad \underset{(r \times r)}{C_2(t)} = \begin{bmatrix} 0 & & & \\ & C_{22,2}(t) & & 0 \\ 0 & & \ddots & \\ & & & C_{rr,2(t)} \end{bmatrix} \quad (8)$$

and thus

$$\underset{(r \times r)}{Q_1C_1(t)} = \begin{bmatrix} {*}q_{11,1}C_{11,1}(t) & & \\ & {*}q_{22,1}C_{22,1}(t) & \\ & & 0 \\ 0 & \ddots & {*}q_{rr,1}C_{rr,1}(t) \end{bmatrix} \; (9) \qquad \underset{(r \times r)}{Q_2C_2(t)} = \begin{bmatrix} 0 & {*}q_{12,2}C_{22,2}(t) & 0 \\ 0 & & \\ & \ddots & \\ 0 & 0 & {*}q_{(r-1)r}C_{rr,2}(t) \end{bmatrix} \; (10)$$

where $C_{22,2}(t)$ represents the value of $C_{22,2}$ at time t.

This means that if we substitute (4) (explicitly stated) into (2) above, we obtain

$$\bar{n}_j(t+1) = \sum_{l=1}^{s} \{ \sum_{i=1}^{r} \bar{n}_i(t)({*}q_{ij,l}C_{ij,l}(t))\} + R(t+1)P_{oi}$$

$$j=1. \quad r \quad t=1,2,3,\ldots \qquad (11)$$

which when re-expressed in matrix form becomes (3) above.

It is also important in the secondary school system to take explicit account of male and female transition proportions as these historically differ significantly. Using four basic markov models for the secondary school system viz: Government Schools - Males, Non-Government Schools - Males, Government Schools - Females, Non-Government Schools - Females (i.e. $k = 1,2,3,4$) the markov model finally used is:

$$\bar{n}_k(t+1) = \bar{n}_k(t) \sum_{l=1}^{s} (Q_{lk}C_{lk}(t)) + R_k(t+1)_{Pok} \qquad (k=1,\ldots,4) \qquad (12)$$

Recruitment was not considered, as the model could run for some five years before its effects impacted upon School Year 12[3], well outside our short-term horizon.

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3. The other Years have some intake but it is assumed quite reasonably to equal the losses between years (i.e. net migration is zero). This migration would most likely be due to (interstate) transfers.

The model was then fitted with the transition proportion being calculated for each t (1975-1979 inclusive) via:

$$Q_{ij,t} = (SY_{j,t} - SR_{j,t})/SY_{i,t-1}; \; j = t + 1 \qquad (13)$$

$$Q_{ii,t} = SR_{i,t}/SY_{i,t-1} \qquad (14)$$

where $SY_{j,t}$ is the number of students in Year j time t
$SR_{j,t}$ is the number of students repeating Year j in time t
$SY_{i,t-1}$ is the number of students in Year i, in time t-1.

Table 2 below summarises the promotion rates for males and females, Government and Non-Government schools for post-compulsory school years.

Table 2

POST-COMPULSORY SCHOOL YEAR ESTIMATED PROMOTION RATES (a)

Government Schools			Non Government Schools	
Males	Females	(b) Promotion from/to	Males	Females
.8473	.8533 0.027	9/10	.9494	.9606
.6390	.7205	10/11	.8588	.8946 .
$.42^{*} (.9393)^{t}$	$.54(.9397)^{t}$ *	11/12	$.7398t^{-.055}$ **	$.74(.97)^{t}$

(a) The compulsory school year rates were constant and around 1.
(b) In School Years.
*, ** denote significance at 5% and 1% respectively.

It is interesting to note that in Government schools the participation for males and females for School Year 12 is diminishing at the same rate, differing only in the base. The Non-Government situation is a reflection of this also, with only the base being considerably larger. This is explained by an expected higher participation rate per se together with the fact that the Government School System has a large number of Technical School students leaving at the end of School Year 11, a fact not shared by the Non-Government Systems.

Based on stocks of students in the various 'states' as at 1975 (30th August) and projecting forward using the model in (12) above, estimates were obtained for stocks of students in both school systems for males and females for School Year 12.

The remaining operation is to estimate the success rate of these stocks of students in the HSC examination which will then yield the eligibles. This is summarised by the model in equation (15) below:

$$\hat{E}_{t+1} = Pr(p/m).\ \bar{n}_{12}^{m}(t) + Pr(p/f)\ .\bar{n}_{12}^{f} \qquad (15)$$

where $\hat{E}_{t+1}$ is the estimated eligibles for Year $(t + 1)$ given we are at t

$Pr(p/m)$, $Pr(p/f)$ are the probabilities of passing the HSC examination for males and females respectively;

$\bar{n}_{12}^{m}(t)$, $\bar{n}_{12}^{f}(t)$ are the expected numbers of students in School Year 12 at time (t) according to male/female classifications. (Government Non-Government differentiation is not used here because of lack of data pertaining to $Pr(p/m)$ and $Pr(p/f)$)

the forecasts obtained from this model were excellent for 1981 and 1982[4].

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4. In 1981 for example estimated eligibles was 14585 and actual was 14609!

FORECASTING INCOME AND YOUTH UNEMPLOYMENT VARIABLES

These two variables were forecast in a more straightforward and conventional way using predictive (extrapolative) approaches and in the case of youth employment published forecasts. The generation of these forecasts is sufficiently standard and uninteresting so as not to warrant further consideration in this paper.

The forecasts for the tuition fees variables was again taken from published government intentions - i.e. that no tuition fees were to be re-introduced (after their cessation in 1973). This publicly expressed policy statement was taken (naively) at face value.

FORECASTING THE DEMAND FOR TERTIARY EDUCATION

With the estimation of the underlying demand relationship (depicting the demand for tertiary education) and the subsequent forecasting of the independent variables, obtaining forecasts for demand for tertiary education was then a simple matter. The generation of confidence limits per se was not considered appropriate due to the large amounts of error inherent in some of the independent variables forecasts, however, 'subjective' confidence limits were used.

CONCLUDING REMARKS

General conclusion to the forecasting methodology.

The task at hand, that of providing short term to medium term forecasts for the demand for tertiary education by successful Higher School Certificate candidates in Victoria, was adequately met by the use of an econometric model representing the demand function, and a markovian model for forecasting the eligibles.

Considerable information was obtained about the demand characteristics of this 'market' from their estimation of the demand function. Additionally, much information about the secondary school system in Victoria was obtained from the markovian model set up to represent it.

Finally, the operation of these two models, and the forecast data on income and youth unemployment allowed the main objective of the study to be attained, namely forecasts of the likely demand for tertiary education by the biggest single component of the market.

However, apart from the technical achievement, together with the added understanding and insights obtained about the demand function and eligibles market, little was achieved by this study in terms of forecasts.

Many A Slip Twixt The Cup and The Lip

The statement above, pertaining to the forecasts obtained being of little value, was made quite sincerely based on the following scenario.

Subsequent to the forecasts being produced, a number of changes occurred to what had been a relatively stable system. Some of the changes were immediate, others throughout the time span of the forecasts.

Some of the changes encountered were as follows:

- the census date for the Secondary School System was changed to July 30 from August 20 rendering data and the markov model incompatible with data post 1981;

- the technical school system (a part of the Government Secondary School System) had during the time period of the study operated without a Year 12. This was subsequently changed, thus rendering transition and to some extent wastage rates useless;

- Government policy suffered a considerable change post 1982, when considerable encouragement was offered to students to remain within the system until completing Year 12 (HSC), again causing changes to the transition rates in the markov model;

- This general encouragement by Government to secondary school students to stay on and complete HSC, lead to a situation where:

  a) Demand for tertiary places now exceeded supply, thus invalidating the demand model in this paper that was predicated upon a converse situation;

  b) Different TEAS (as it was called during the time of the study) allowances were introduced, thus complicating matters even further;

- A massive expansion of the Technical and Further Education (TAFE) sector with associated publicity may well have impacted the tertiary market.

- The general economic picture post 1981 became bleaker than anticipated and youth unemployment was found to be quite substantially under-estimated.

- There was a flood of students into the Non-Government Secondary School System around 1982/83, that appeared to be at all secondary years (not just School Year 7) thus causing a further structural change.

- Last but not least, there was considerable discussion in government circles regarding the re-introduction of tertiary tuition fees, which finally culminated in 1987 with the introduction of an 'Administration Fee'!

With the above changes the forecasts were made useless. This did not invalidate the forecasting effort however, as much was learned about the secondary school system and the tertiary education market.

What these events do point out however, is that forecasting is still an art form and that the operation of its fundamental premise (that what has happened in the past will continue into the future) is rarely, if ever, valid. Thus forecasters, especially when using sophisticated models, must remember there's many a slip twixt the cup and the lip!

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