A DYNAMIC MODEL FOR A FEDERAL SYSTEM OF HIGHER EDUCATION

Peter L. Galbraith, BSc., DipEd., MSc., PhD., Senior Lecturer in Education, University of Queensland, Australia.

Peter Galbraith trained and practised originally as a mathematics teacher. He completed an MSc in mathematics (fluid dynamics) at Melbourne University (1972).

Since 1974 he has been in charge of preparation courses for teachers of mathematics at the University of Queensland, with a research interest in the development of mathematical thinking in young students.

A concurrent interest in applied mathematics has been transferred to problems involving educational systems and in 1982 he completed a PhD involving the application of system dynamics methodology to a future study of the higher education system in Australia.

ABSTRACT

This paper describes aspects of the construction and operation of a model designed to illuminate possible alternative futures for the higher education system in Australia.

After the context of the problem has been set some representative mechanisms are discussed for operations within the school, university, and labour force sectors of the model.

A discussion of simulation output samples from the range of policy evaluations and system conditions that were encompassed in the study. These include the effects of postulated changes in social and labour force conditions such as reduced working lifetimes, changes in the pattern of student progression from school to tertiary education, and the effects of various policies such as those which relate to the balance between school leavers and mature age enrolments. Implications of some of the simulation data for the system are considered.

1. INTRODUCTION

Within the Australian context Universities and Colleges of Advanced Education (CAEs) may be defined as comprising the *higher education* sector in that with certain exceptions for some mature age students entry into undergraduate courses is by matriculation from grade 12 of secondary school, with selection determined on the basis of a tertiary entrance score. The secondary courses which lead to acceptance are academic in nature and the graduates of the institutions compete for employment in the professional sector of the labour force. In the sense that both universities and CAEs draw from the same pool of potential students and offer some courses in similar areas they may be seen as competitive, as well as complementing each others' function in areas where their courses are distinctive. It therefore makes sense to model a problem in which both types of institutions are key components.

Higher education, because it is totally funded by the Federal Government is dependent upon the priorities of the government. Being labour intensive it is becoming increasingly more expensive and must compete for monies with other areas of federal responsibility such as defence and social security. As a consequence of having to compete, education is becoming increasingly politicized, and since change of government priorities can take place rapidly in comparison with the rate of change within the tertiary sector, the resultant disruption tends to produce an opportunistic approach to planning for universities and colleges.

Rate of technological change is also rapid and is causing disruption in the labour force in its own right. This, in turn, leads to further questioning of the relevance of higher studies.

Parallel to the changes in technology are social changes which are equally dramatic. These have seen, for example, many more women enter and remain in the workforce, a major increase in the proportion of females in higher education and a sustained, increasing demand for higher education on the part of mature age students.

Attempts to project future trends have typically been based on assumptions concerning future movements in the labour force, productivity, population, participation rates in higher education, and retention rates at secondary schools. Projections made on the basis of such assumptions, have treated them as separate influences each contributing to the final projection. In the real world, these factors are not independent, since, for example, employment opportunities influence participation rates in courses leading to such employment. Conventional methods of projection are not equipped to cope with a system which contains interacting feedback processes within its structure and consequently a system dynamic methodology was adopted.

The present article discusses aspects of the development of a dynamic model which describes the interaction between higher education, the labour force, and society within the Australian context.

The model has been used to explore the possible consequences of changing labour force and social conditions, and the consequences of various policy decisions.

Figure 1 contains a casual diagram for part of the model. The arrows in this diagram merely denote casual relationships without regard to delay or sign. Indeed, the polarity of some loops varies according to the parameterization and the state of the model at a particular time. The system of higher education is assumed not to influence the number of students of grade 12 age in the community so that this variable appears as an exogenous input. Similarly the total labour force as defined in this model is deemed to be effectively insensitive to influence from within the system. It suffices to observe that, for example, the number of farmers and clerks in the labour force is not significantly affected by movements within the system of higher education. The pro-

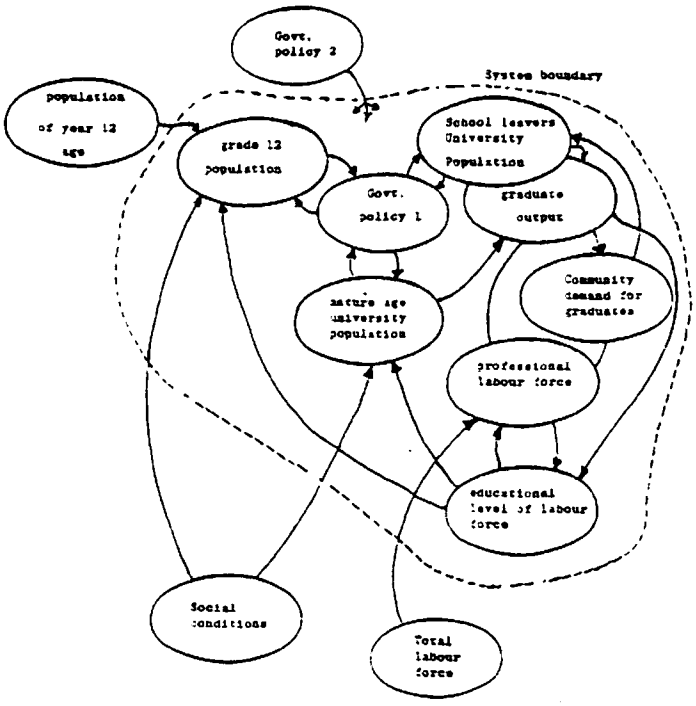


Figure 1.

fessional labour force on the other hand is within the model boundary for it both influences and is influenced by higher education.

Social conditions at this level of aggregation can include factors such as the capacity of parents to keep children at school or an increasing drive for independence on the part of married women. The influence, denoted social conditions in the casual diagram, represents those societal factors which influence the higher education system without being effectively influenced in return. There are other important social factors such as unemployment which are within the system boundary. In the present instance such factors are encompassed within the descriptor entitled community demand for graduates.

Government policy is shown as two components, one of which is endogenous to and the other of which is exogenous to the system boundary. The endogenous contribution allows for those policies which may be regarded as built into the system. For example, an increase in year 12 population may under normal circumstances be expected to stimulate some corresponding increase in university and college places. Since any such increase needs the support of the funding agency (government) it is useful to regard government policy as a mediator between senior school population and the enrolment populations of universities and colleges. This is represented in the casual diagram as government policy 1, and is responsive to supply and demand forces generated within the system. There is a sense, however, in which government policy needs an exogenous component; government policy 2.

This exogenous variable can be used to override the endogenous contribution where necessary. For example, to model a freeze on enrolments at universities and colleges the exogenous component can be applied to override the response to the supply and demand conditions which normally obtain between institutions of higher education and their feeder populations.

2. IDENTIFICATION OF SYSTEM DESCRIPTORS (State Variables)

For the present study at a high level of aggregation, the following state variables were chosen as essential to adequately describe the system.

1. Population of grade 12 students at school.
2. Number of undergraduates at institutions of higher education who entered directly from school.
3. Number of undergraduates at institutions of higher education who are mature age enrolments.
4. Graduate unemployment.
5. Number of jobs in the community available for graduates.
6. Number of graduates in the professional labour force.

Subsequently it was realised that this level of aggregation was too broad to meaningfully attack the problem being modelled and consequently other levels were introduced. For example, it was found necessary to divide the university population from the college population, and within these respective sectors to subdivide further according to whether courses were unique to one particular kind of institution or were represented in both. This allowed the distinctive and competitive aspects of the respective sectors to be separated from one another.

3. MODEL FORMULATION

For purposes of formulation the model was divided into sectors which resemble, as far as possible, the corresponding real world components. Some representative model mechanisms will be discussed by way of illustration.

3.1 Year 12 School Population

During the period of rapid expansion of education (1960's) the growth in the year 12 population and in higher education enrolments considerably exceed the rate of increase that was to be expected on the basis of population movements alone.

Three further factors were considered in relation to this growth in enrolments:

(a) Quality of life issues,

(b) Effects of Credentialism,

(c) Labour force balance (perceived opportunities and relative rewards).

Available evidence from research studies such as[1] suggests that the system of higher education does not feed back to cause significant shift in social attitudes such as would tend to substantially increase the potential enrolment in higher education. Further, the higher quality of life which enabled those with appropriate values to provide an extended education for their children could not be attributed, as an outcome, to the system of higher education in its earlier, depressed, state. In summary it did not seem reasonable to include these socio-economic influences within a feedback structure endogenous to the model boundary.

Within the model, a variable RPG was used to denote the rate of growth of the population of year 12 age, and this basic rate, (modified by multipliers) was used to determine the year 12 enrolment. A quality of life input can be used to modify the entries in the table function that defines RPG as a function of time. In this way exogenous influences on retention rates can be incorporated.

3.2 Effects of Credentialism

As observed in the Williams Report[2].

There is a tendency for a rise in retention rates in schools and a rise in participation rates in post-secondary education to create pressures for a further rise in those rates.

The compounding effect is caused by employers changing their patterns of recruitment to take in young people who have shown the necessary ability and energy to pursue their education. Recruitment is determined more by the level of qualification than by the relevance of the particular training. The effect of credentialism is passed down the educational line. Thus, just as some employers now require a degree or diploma as a proxy for suitability, so others begin to demand a year 12 qualification where once, a year 10 certificate would have sufficed.

Thus there is incentive to complete secondary school, not only for those who wish to continue to higher education, but also for many who seek employment in 'white collar' occupations.

Figures from the 1976 census show that of all employed holders of tertiary qualifications, more than 75% are to be found within the professional sector (category A) of the labour force. Category A, redefined for model purposes as the Professional Labour Force (PLF), is the sector of the labour force in which new graduates seek employment. It is estimated that approximately 90% of new graduates have been absorbed into the PLF during times of buoyant employment.

A ratio defined as the *Tertiary Educated Level of the Work Force* (TELWF) was used as the abscissa variable from which to generate multipliers embodying effects of credentialism. TELWF is the proportion of the PLF holding tertiary qualifications. The higher the value of TELWF the greater the proportion of employees with tertiary qualifications and the stronger the pressure on aspiring employees to obtain superior qualifications in order to compete. Thus an increase in TELWF encourages more students to qualify themselves for higher education. Other things being equal this in turn leads to an expansion in the numbers enrolled in higher education courses, and thence to an increase in the output of graduates and diplomates.

These new degree and diploma holders enter the professional labour force so raising its educational level still further. The positive feedback cycle is completed and there is then a further pressure on retention rates, whence the cycle begins again.

3.3 Labour Force Balance

Real world observations arise from a combination of effects and rates of enrolment can decrease even when subjected to upward pressure by factors such as credentialism. This can happen for example if there is substantial graduate unemployment or if the incomes of technicians and tradesmen rise relative to the incomes of graduates and diplomates.

The Williams Report[2] noted that "The income advantages that accrue to those in employment with tertiary qualifications were less in 1973-74 than they were five years earlier". Labour Force statistics indicate that the PLF increased from 8.4% to 11.8% of the total labour force, while simultaneously the trades sector fell from 36.3% to 29.9% over the 15 year period to 1976. The low professional component in the early sixties is characteristic of the climate in which early reports such as[3] and [4] expressed the urgent need for an expansion of the higher education system. By the mid seventies concern was being evident about an emerging shortage of tradesmen.

Taken with the decrease in relative wage advantage already noted, and the suggestion of graduate unemployment, the levelling of the retention rates for males in the mid-seventies is seen as strongly influenced by the shift in the composition of the labour force. When attractive employment openings exist, without the need to undergo the rigours of higher education, there will be a tendency for more students to accept those openings.

The ratio of the professional labour force to the total labour force, (PLFR), is used as a variable from which to influence year 12 retention rates according to the balance existing in the labour force. The effect of the associated multiplier will augment growth when PLFR is low and inhibit or reduce growth when PLFR becomes too high.

With respect to feedback mechanisms it is seen that a low value of PLFR will encourage students to qualify for lucrative opportunities within the PLF. Relative wages will be high due to the shortage of qualified manpower. The resulting rise in retention rates will lead to increased enrolments in higher education and thence to an increase in the output of qualified personnel. Employment of the increased number of graduates will tend to reduce the imbalance in the labour force so reducing the relative employment advantage and hence the attractiveness of further study. Hence the pressure to increase retention rates is eased. The labour force balance feedback loop is thus a negative loop.

The labour force interaction with retention rates at secondary school is thus represented in the model by the combination of a positive feedback loop (credentialism) and a negative feedback loop (labour force balance).

3.4 Undergraduate to School Density Ratio

A further influence on the rate of growth of year 12 enrolment is the size of that enrolment relative to the number of available places in undergraduate courses. A variable UGSDR was defined as the ratio of total undergraduate enrolments to three times the current year 12 school population. The value of this ratio increased from 0.50 in 1969 to 0.64 in 1978.

While in general no effect on retention rates is to be expected when the value of this ratio varies broadly in the middle of its range, this will not be true if the ratio reaches extreme values.

If the value is very low this means that there are very few available places in higher education in relation to the year 12 population seeking access. This situation will cause some students to seek other avenues rather than striving to qualify for a place they see themselves as unlikely to get. Hence the rate of entry into year 12 will be *inhibited*.

When the value of the ratio is very high the institutions of higher education will be drawing from a reduced pool of potential students. This means that if all places are to be filled the quality of some of those accepted will cause concern. In such circumstances a policy initiative will be introduced which is aimed at increasing the year 12 enrolment. This initiative is built into the system as a mechanism which is stimulated into action whenever the density ratio becomes too high. As such it is endogenous to the model boundary for it is directly linked to system conditions. This distinguishes it from an exogenous effect which can be introduced at any time, e.g. for reasons of political philosophy or to represent a change in living standards rather than as a planned response to system conditions. An historical precedent exists for such a mechanism in the scholarship system which operated during the 50's and 60's for the purpose of encouraging more students to complete secondary school. The motivation was the need to increase the pool from which students could be recruited to train as secondary teachers in a time of great need. The award of Commonwealth Secondary Scholarships during the sixties had the similar intention of increasing the proportion of students completing secondary school. In this case there was no specific bonding to a particular tertiary course or mode of employment. In system terms the mechanism described here forms part of a negative feedback process which comes into action only when conditions reach a critical phase as defined by the value of the UGSDR variable.

3.5 Intake to University

Students who successfully complete year 12 of secondary school have at least three immediate options. They may,

(a) elect to enrol full-time in a university course,

(b) elect to enrol full-time in a C.A.E. course,

(c) elect to enter the labour force and perhaps continue studies on a part-time basis.

During this final schoolyear students must formally apply for places in higher education, order their preference for a university of C.A.E, and seek acceptance into specific courses within the chosen institution.

An historical method of estimating undergraduate enrolments in universities has been through the use of the participation rate, defined as the fraction of the 17-22 year old cohort attending university.

However, the increasing proportion of mature age students has made the participation rate a less reliable predictor than it once was.

The first stage of disaggregation involved the decision to treat school leavers and mature age entrants as two separate populations within the university system. This decision was motivated not only because of the different source populations, but also because the respective groups differ (at least in part) with respect to methods of entry and reasons for participation in higher education. The disaggregation represented by the separation of school leaver from mature age enrolments is not sufficient for the problem addressed by the model.

Reference has been made to the existence of competition as well as complementation between universities and CAEs. This feature needs representation within the model structure, and consequently two sub-levels were defined for the population of undergraduates who enter direct from school. These levels have been defined respectively as:

NUGAS – number of undergraduates enrolled in academic courses direct from school, and

NUGHUS – number of undergraduates enrolled at university in general higher education courses direct from school.

The NUGAS level contains undergraduates enrolled in academic courses specific to universities, from which there is no substantial competition within the college sector. Typical courses include medicine, dentistry, veterinary science, but also areas such as languages and psychology. The NUGHUS level contains undergraduates enrolled at university in general higher education courses. These courses are defined to be those for which there is some counterpart in the C.A.E. system. There is thus competition between institutions for students, and between graduates of the respective institutions for employment. Typical courses within this classification include the sciences, engineering and some education and arts courses. The relative magnitudes of the two classifications were estimated from statistics of enrolments according to area of study.

3.6 Factors influencing growth rates of NUGAS and NUGHUS

The Exit Rate from University of the School entry undergraduate population (ERUS) is defined by the sum of graduation and discontinuation rates. At the level of aggregation being used these rates are applied to both the NUGAS and NUGHUS levels. ERUS defines a basic entry rate for new students through vacancies created by the existing students. This basic rate is modified by multipliers which reflect societal factors affecting growth.

During the growth periods of higher education the rate of increase of university enrolments rose synchronously with (although at a lower rate than) the rate of increase of senior secondary school enrolments. This information points to the existence of a policy which related university funding to pressures induced by movements in senior secondary school populations. That the policy also acts to reduce rates of funding when pressures on intakes are reduced has been made obvious in recent budgets.

A "flow-on" multiplier is provided in the model to adjust university enrolments in line with movements in the year 12 enrolment. This multiplier acts as an inbuilt policy mechanism and its effect can be overriden by the imposition of exogenous policy initiatives introduced at any time irrespective of the state of the system.

In making decisions to complete secondary school, students are influenced by the general labout market and the opportunities and relative rewards associated with the attainment of a higher qualification. Once having qualified for entry to higher education, students are more concerned with opportunities, which at this decision point, are associated with particular courses at particular institutions. Graduate unemployment in certain sectors of the labour force will cause students to refrain from enrolling in associated courses so leaving student places unfilled.

An illustration of this effect was seen in Queensland where media publicity about a projected teacher surplus resulted

in a large drop in applicants for places in teacher training courses for 1980.

In on the other hand an acute shortage of qualified personnel begins to impair the economic and social development of the nation, then an expansion of university places may be provided for independently of growth initiated by population pressures.

These feedback loops linking enrolment rates with employment opportunities are negative loops.

A final effect on intake rates for the purpose of this model is that produced if the density ratio UGSDR becomes too high. When this happens the ratio of enrolled undergraduates to year 12 students has risen to the extent that there is a problem in filling all available places with students of sufficient quality.

An effect will be felt by the NUGHUS population for some of the quota places will be left vacant due to the unacceptably low year 12 performance of aspiring students. The effect will be compounded by the fact that a number of the best students, who in normal times would have enrolled in NUGHUS courses, will obtain places in NUGAS courses instead.

3.7 Mature Age Enrolment at University

Substantial growth in the numbers of mature age undergraduates has been a feature of the university system well before it began to attract the public notice of educational planners. University statistics indicate that while mature age and school leaver undergraduates grew at the same average rate in the decade to 1971 the mature age growth continued unabated in the fact of reducing rates of increase on the part of school leaver enrolments.

The implications of continued growth in mature age enrolments is considerable and is another major reason why the mature age undergraduate population has been separated as a level variable from its school leaver counterpart.

3.8 Characteristics of Mature Age Undergraduates

Mature age students qualify for university either by conventional methods of matriculation of as "special entry" students. Special entry students are students accepted without formal matriculation qualifications.

Conventional mature age students are admitted because they have either recently, or in previous years, gained the equivalent of sufficient matriculation points to qualify for admission. Many such students will have qualified through evening course studies while engaged in full-time employment.

Special entry students are accepted at the discretion of faculty and their admission in large numbers depends upon the availability of places. Mature age enrolment is stimulated by a combination of vocational and social influences.

The importance attached to enhanced vocational prospects has been documented in surveys such as[5] in which mature age respondents acknowledged the pressure exerted by the need to meet job demands or to qualify themselves for promotion.

The educational level of the labour force is an obvious factor behind such decisions to undertake higher education.

The social influence is defined for model purposes in terms of an amalgam of properties, collectively defined as *Social Conditions* (SCD). The social conditions concept includes influences such as the increasing drive for women to gain and retain indpendence, the increasing number of single parent families, effects of the information explosion, heightened awareness of social problems, and the need for individuals to seek personal satisfaction and fulfilment in their lives.

It can be argued that an increase in the complexity of society is facilitated by the level of complexity that already exists. New directions and new movements are given impetus by the number of individuals already participating in them, through the publicity and respectability that mass acceptance brings. The existence and acceptance of many different values makes it easier for still other values to be introduced and accepted.

The social conditions level is assigned a growth rate to represent its growth characteristic. Its influence in increasing the demand for higher education is represented by a multiplier.

Effects of possible increases in non-work time have not been included in the above conceptualisation. As a variable, non-work time is not subject to exponential growth. The creation of an additional unit of leisure time is not facilitated by the amount of free time already in existence. There are several potential sources for increases in non-work time of which the most dramatic is the development of computer technology.

Changes in available leisure time are incorporated in the model by such measures as altering values in table functions that transmit vocational and societal effects, and by altering coefficients that define the balance between full-time and part-time enrolments.

3.9 Control of Mature Age Enrolment

The rate of increase of mature age undergraduates at universities, would, if maintained at the average level sustained between 1961 and 1976 produce a population of 307,000 mature age undergraduates by the year 2001. Clearly continued growth of such magnitude is beyond the range of feasibility for the present system on grounds of finance alone. Recent figures indicate that the rapid growth is continuing.

Many mature age students are already employed so that graduate unemployment does not have the same inhibiting effects on enrolments as it does for school leavers. For example mature age demand retained the same average rate of increase throughout a variety of changes in opportunities for graduates between 1961 and 1976. At the University of Queensland enrolments among students aged over 40 years grew at an average annual rate of 6.8% in the decade to 1982.

Consequently, no strong negative feedback mechanism is presumed to link the demand for undergraduate places on the part of mature age students with prevailing conditions of graduate employment.

In the absence of naturally occurring controlling influences, and given that pressure on intakes is expected to increase for reasons previously advanced, some policy mechanism will be necessary to control rates of growth. This part of the model mechanism involves the introduction of a policy which has not been invoked in the historical past.

The central aspect of this policy resides in the balance of enrolments as defined by the respective numbers of school leaver and mature-age undergraduates. If the ratio of mature

age to school leaver enrolments continues to increase as in the past the system of higher education will eventually be seen as catering principally for mature adults rather than as providing an extension of education for school leavers.

The model structure contains mechanisms which can limit the mature age undergraduate enrolment to a maximum arbitrary multiple of the corresponding school leaver enrolments. In 1976 the ratio of mature age to school leaver undergraduates was 0.50, having risen from the figure of 0.38 in 1971.

The value of the arbitrary maximum assigned to this ratio can be chosen at will and was set at 1.5 in a basic formulation of the model. This means that mature age enrolments can grow under normal pressures but will be curtailed at values which do not exceed 1.5 times the corresponding school leaver enrolment.

The maximum value (1.5) can be varied for different runs of the model, and also from sector to sector within a given run. Thus for example the upper limit might be retained at 1.5 for students enrolled in general higher education courses, but restricted to 0.6 in the more specialised academic courses. This would amount to keeping academic course enrolments in favour of school leavers while allowing for mature age expansion in more general areas.

The numerical value of the limiting ratio is also related in the model to the prevailing employment situation. When conditions for graduate employment are buoyant the mature age growth is allowed to proceed to the maximum level defined by the limit. However, under conditions of graduate unemployment the upper limit is reduced so providing a measure of protection for school leavers.

Finally the lifting of all limits can be used to model a 'free-trade' approach. As indicated previously such a scenario has immediate financial implications for the system as presently constituted. However, for futures such as those envisaged by Vaughan and Sjoberg,[6] where life-long, continuing education is seen as desirable, the lifting of the limits provides a purposeful alternative. If applied differentially within the university – college system, the lifting of limits can be used to project community college scenarios.

The imposition of a policy ceiling on the number of mature age undergraduates will produce a social feedback influence to the demand rates for higher education courses.

When the available 'quota' of mature age students has been filled, those still desiring a university education form a theoretical queue.

As students leave the university system by graduation or discontinuation new places become available and are filled from members of the aspirant population not already enrolled.

Simultaneously the aspirant population is augmented by new arrivals some of whom may 'jump' the queue because of particular qualifications of abilities that they possess. If the number seeking entry is large compared with the number enrolled then the disappointed fraction of aspirant students will be large.

When this occurs a choice emerges between a potentially long and risk-associated waiting time and a decision to pursue other interests. Under these conditions many will decide on the latter alternative, social communication processes will ensure that the corresponding publicity spreads, so that future aspirants will be deterred from seeking entry to courses. Pressure for entry will thereby be reduced until the disappointed fraction of aspiring students has reached a figure sufficiently low to make acceptance into courses reasonably likely. These improved prospects will begin to attract more potential students whence pressure for entry increases and the cycle begins again. This negative loop acts to counterbalance the growth factors imposed by the vocational and social drives.

4. THE LABOUR FORCE

Between 1961 and 1976 the growth of the total labour force (LF) averaged 2.1 percent per year while that of category A, the professional labour force (PLF), averaged 4.5 percent.

Since graduate employment is heavily concentrated in category A the movement of the PLF relative to the LF is important in determining employment opportunities for graduates from universities and CAEs. The labour force as a whole contains many sectors which do not interfact in any substantial direct way with the system of higher education. For example, in 1976, whereas persons with higher qualifications comprised 52.7 percent of the PLF such persons comprised only 2.3 percent of the remainder of the labour force. Of this residue the greatest relative concentration was in the executive and managerial category, a category not generally accessible to new graduates.

Consequently the PLF has been chosen as the key labour force variable for purposes of formulation.

The principal organizing concept used in defining the labour force subsystem has been the notion of labour force balance. The present model structure provides mechanisms which enable growth estimates for the PLF to be made given typical assumptions concerning the projected growth of the total labour force (LF) such as are found in[7].

For this purpose the growth of the PLF is assumed to be determined by

(a) growth rate of LF,

(b) growth rate of PLF relative to LF.

The clearest way to visualize the use of the balance concept is to consider the extreme case in which the LF is entirely made up of persons in the professional sector (PLF = LF). This situation is clearly impossible for it would imply a labour force without farmers, tradesmen or indeed any manner of worker outside the professional area. Hence some limiting proportion exists for the PLF as a fraction of the whole.

On the other hand between 1961 and 1976 the PLF grew at approximately twice the average rate of the labour force as a whole, during which time the fractional contribution of the PLF to the LF rose from 8.4% to 11.8%. This strong relative growth indicates that in 1961 the PLF was relatively depressed at .08 of the LF, a fact implied by the recommendations of the Martin report[4].

Such strong relative growth cannot continue indefinitely for in time this would take the PLF beyond the limiting proportion discussed above. The model mechanism utilizes the ratio $\frac{PLF}{LF}$ (PLFR) as an equilibrating factor which via a multiplier increases or decreased the rate of growth of the PLF accordingly as the value of the ratio is relatively low or high.

The choice of an upper limit for the value of PLF/LF consistent with an efficient labour force is a matter of estimation. Historical data indicates that it exceeds 0.12 at least. The model mechanism provided gives the modeller freedom to consider a range of options by the simple expedient of changing table values. Continued growth of the PLF is represented by choosing the limiting value of PLF/LF to be relatively high. Rapid curtailment of the growth of the PLF is achieved by choosing a more conservative limit.

5. STRUCTURE WITHIN THE PLF

With the professional labour force a simplu dichotomy is drawn between those with higher (tertiary) qualifications and those without. The former category is then associated with the four classifications of graduate identified with the university and college subsystems.

These classifications are respectively,

* graduates with academic skills (university only),
* graduates with technical skills (CAEs only)
* graduates with teacher education skills (CAE training courses),
* graduates with general higher education skills (universities and CAEs).

The teacher education component is treated separately as it refers to those teachers (mainly primary teachers) whose demand is determined by population growth, resignation rates, and policies with respect of pupil-teacher ratios.

Employment for the balance of graduates is generated as industry, commerce and public utilities generate growth and development patterns. It has been found useful to define a Residual Professional Labour Force (RPLF) by subtracting from the PLF those jobs which are specifically identified with the teacher education component as defined above. This residual labour force is then the desired source of employment for graduates in all other categories and for professional workers without higher qualifications who provide support and complementation within the PLF.

In times of graduate unemployment it may occur that qualified personnel will accept positions for which their skills are excessive, and which are not professional in nature. This leads to the notion of an *underemployed* work force.

The following level variables have been introduced to aid the formulation of the labour force sector of the model.

JAS – jobs in the PLF for graduates with academic skills,

JHS – jobs in the PLF for graduates with general higher education skills,

JTS – jobs in the PLF for graduates with technical skills,

JES – jobs in the PLF for graduates with education skills.

Initial values for these levels were estimated from labour force data as were resignation rates. Historical growth rates for the levels were estimated from information concerning the rate of production of graduates over a period of years.

The concept used to obtain a basic growth representation for the model mechanism was again labour force balance, this time applied within the residual professional labour force (RPLF). (JES was subtracted out because its mechanism is essentially different with growth being determined by rate of population growth and policies with respect to pupil-teacher ratios).

Table functions allow for modification of the growth rates of levels such as JES as a function of their proportion of the RPLF. The multipliers augment (or inhibit) the growth rates according as the proportional contribution to the RPLF is depressed below (or close to) arbitrarily chosen but historically reasonable limits consistent with a balanced and efficient labour force.

Two further effects are represented by multipliers to the rate variables:

(a) Shortages of qualified labour inhibit the rate at which growth and development can occur. Hence when a graduate shortage (negative unemployment) occurs a multiplier acts to reduce the rate of expansion.

(b) When graduate unemployment exists, employed persons become different about resigning from positions in the work-force since prospects for re-employment are seen as depressed. A multiplier is provided which acts to reduce the (standard) resignation rate that is assumed to hold under buoyant employment conditions.

6. UNEMPLOYMENT

Qualified graduates normally seek positions in the professional labour force, for which work demands and rewards are seen as commensurate with the type of education received, and the time investment involved in attaining the qualification.

When the supply of graduates exceeds the available positions there is graduate unemployment. Unemployed graduates may elect to remain unemployed or undertake casual temporary work while waiting for a position more in keeping with expectations and qualifications. Alternatively they may elect to accept permanent employment in jobs for which they are overqualified and in which they do not utilize the advanced knowledge and skills recently acquired. Within the model such persons are regarded as entering the *Underemployed Labour Force*.

In times of graduate labour shortage it is possible for members of the underemployed labour force to upgrade their employment. However, there are factors that work against such a move. Unused knowledge and skills decay quite rapidly so that after some time in underemployment an individual no longer has the capacity to move directly into a position demanding the graduate skills once possessed. Secondly, many persons having come to terms with an altered situation will have established a career pattern and lifestyle which they may be reluctant to alter, and so elect by preference to continue as they are.

In modelling graduate unemployment, provision has been made for a proportion of excess graduates to accept positions in the under-employed labour force. In times of graduate shortage provision has been made for some of the shortage to be alleviated by attracting back workers from the under-employed labour force. In keeping with the proceeding discussion the rate of attraction is considerably less than the rate of movement in the reverse direction by job seeking graduates who find graduate employment prospects bleak.

Apart from these effects the inrate to graduate unemployment is based on the output from universities and CAEs, while the outrate which reduces unemployment is based on the rate of job generation as discussed in the previous section.

Initial values for the unemployment levels have been estimated from societal conditions appropriate to the initial state of the model. In 1975/1976 graduate unemployment was still negligible in all areas except education skills where a teacher surplus had begun to emerge. Hence all initial values were set at zero except for the teacher education category which was estimated from available data. It is emphasized that it is the movements relative to initial values rather than the initial values themselves that are important for model behaviour.

Other sectors of the model were devised to handle higher degree and graduate diploma mechanisms and to provide measures for the cost of the higher education system.

Explicit time delays in the system occur between changes in the rate of growth of year 12 school enrolments and the corresponding tertiary adjustments.

Most delays however are induced by social processes and are implicitly defined through multiplier functions.

For example there is not a fixed time lapse between the occurrence of graduate unemployment and its effect on subsequent intake rates. The effect occurs as a consequence of unemployment becoming 'visible' and typically this visibility is transmitted through percentage unemployment figures. Percentage unemployment is used as the abscissa variable in defining multipliers to the intake rates of corresponding courses.

A simulation period of 40 years was chosen in order to provide adequate time for the period of oscillatory modes to be observed. The integration interval was 0.25. The model was initialised for 1976 conditions this being the latest year for which full census data was available to estimate parameters and initial values.

7. MODEL OUTPUT

The model was subjected to a variety of parameter changes that represent a compendium of changes in societal conditions and policy implementations. In addition to sensitivity tests and policy evaluations some alternative scenarios were constructed to investigate the performance of the system under the stresses imposed by alternative future developments.

Model output across a range of conditions and policies exhibits oscillation as the most characteristic response of enrolment and unemployment levels. These modes have periods that typically extend between one and two decades. Those associated with graduates from shorter courses have shorter periods but in all cases the periods of oscillation are several times the length of a typical tertiary course. The delays inherent in the system mean that the growth of unemployment and the system response that influences enrolment rates are typically out of phase. This mode is presently evident within Australia where enrolments in teacher preparation courses have become depressed as a consequence of publicity about a general surplus of teachers made 5 years ago. A serious shortage of teachers of mathematics and science has developed and the system is not equipped to supply them in sufficient numbers sufficiently quickly.

Parameter changes which model policies of early retirement move workers through the labour force more quickly and generate a sustained increased demand for graduates. The expanded system of higher education needed to meet the long term is costlier and the oscillations generated by employment-enrolment feedback are sharper. Graduate underemployment is generally lower. The system response suggests that from a medium to long-term perspective goals of low unemployment (assisted by policies of early retirement), a small education system (motivated by policies of contained Government spending) and an adequately qualified professional labour force may be incompatible.

The policy which acts to increase year 12 school enrolments in the fact of tertiary intake quality problems has not, in any run in which it has operated, been able to act sufficiently quickly or strongly to prevent further worsening of the problem. Such outcomes stress the need to monitor movements in the school population and to consider policies that will maintain it at buoyant levels.

Some of the most satisfactory output has derived from runs in which the effect of feedback between graduate unemployment and enrolment rates has been suppressed or reduced. Such circumstances require that prospective students be encouraged to enrol in undergraduate courses leading to sectors of the professional labour force in which a measure of unemployment visibly exists.

If an increased measure of underemployment can be sustained this approach has some positive features given that the demand for professional labour continues. The education system is more cost effective since it continues to attract large numbers of school leavers, who as full-time students maintain graduation rates and thence 'efficienty'.

Perhaps the most significant implication for the future of higher education that has emerged from this study is concerned with the unabated growth of the mature age undergraduate enrolment.

Variants of four different policies have been modelled with respect to the future of mature age enrolment. The simulation that allowed unrestricted growth led to system blow out within 15-20 years from the initial timeline.

Of the various control measures adopted most worked on some arbitrarily chosen limiting ratio of mature age to school leaver enrolments. Measures in which this ratio was given flexibility in relation to unemployment conditions proved among the more useful. In real world terms accurate statistical information would be necessary for the implementation of the policy.

Policies which diverted mature age students significantly to the college system had the effect of converting colleges to primarily mature age institutions. The policy was successful in increasing the number of school leavers undertaking higher education – but at the first degree level. This was achieved at the expense of a reduction in higher degree students and the overall shift in equivalent full-time student units to the less expensive college sector was only of the order of 5 percent.

As an example of model output Fig. 2 and Fig. 3 depict graphs for a scenario in which under the influence of uncertain social conditions a major change occurs in the school to work patterns of students completing secondary education, whereby many opt to secure employment and proceed to higher studies on a part-time basis.

Simultaneously a general increase in leisure time and greater personal freedom enable more mature age students to study full-time.

The move to shorter working hours is accompanied by a general increase in retirement rates to reflect an early retirement effect. The corresponding parameter changes are effected in the model run at T = 10. (For the graphs in Fig. 3 values less (greater) than 1 indicate conditions of unemployment (shortages of graduate labour).

After the parameter changes (T=10) there is a substantial increase in demand for graduates in the CDAS and CDHS areas. The CDTS area shows a typically greater rate of oscillation than the two former areas because in general the qualifications leading to employment in this area require a shorter time to achieve. The teacher education area reaches a more equal balance after the dissipation of unemployment caused by overproduction of teachers in the early years of the run.

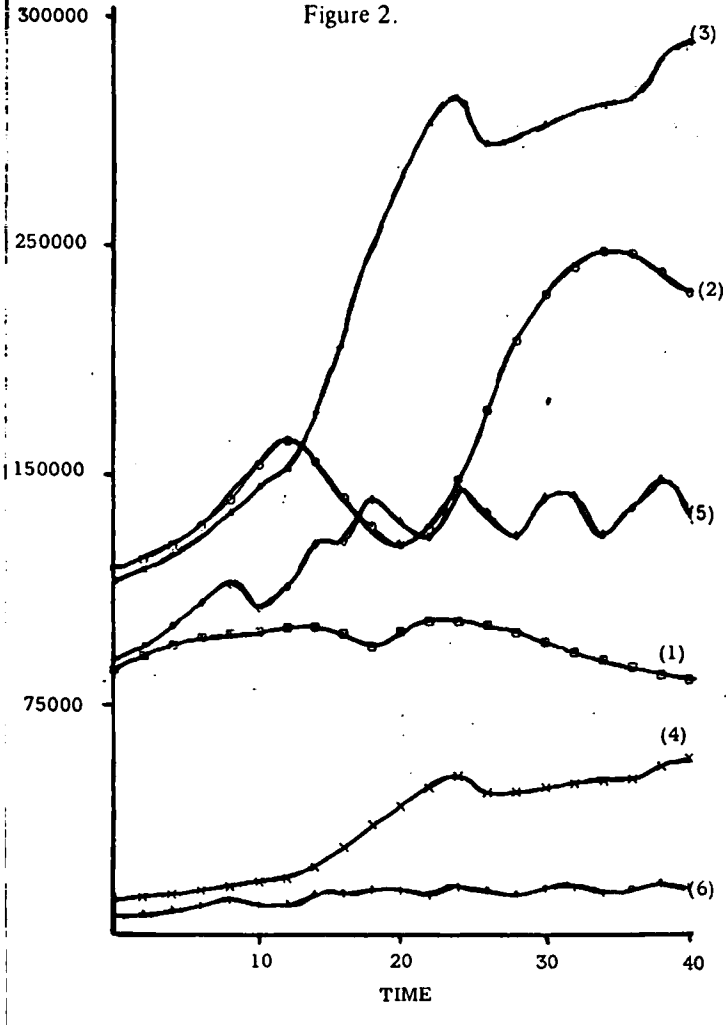
As seen from Fig. 2 enrolment rates respond after some delay. The system is now less efficient in terms of graduation rates on account of a higher proportion of part-time students and the inbuilt delays cause over-compensation to occur. This factor introduces a measure of instability into both unemployment and enrolment variables and this behaviour induces oscillatory properties into other variables such as the underemployed labour force (UNDEMP).

The year 12 population (PLVL) remains subdued in the absence of a driving force from the educated level of the work force which stabilizes at approximately T = 15. This further retards the capacity of the system to respond when a phase of graduate shortage is reached.

The relatively extreme fluctuations generated in this run suggest that management of the education system will be difficult if such a change in school to work patterns and associated factors emerge as a future prospect. Every effort needs to be made to encourage a continuing strong flow of full-time students into the system.

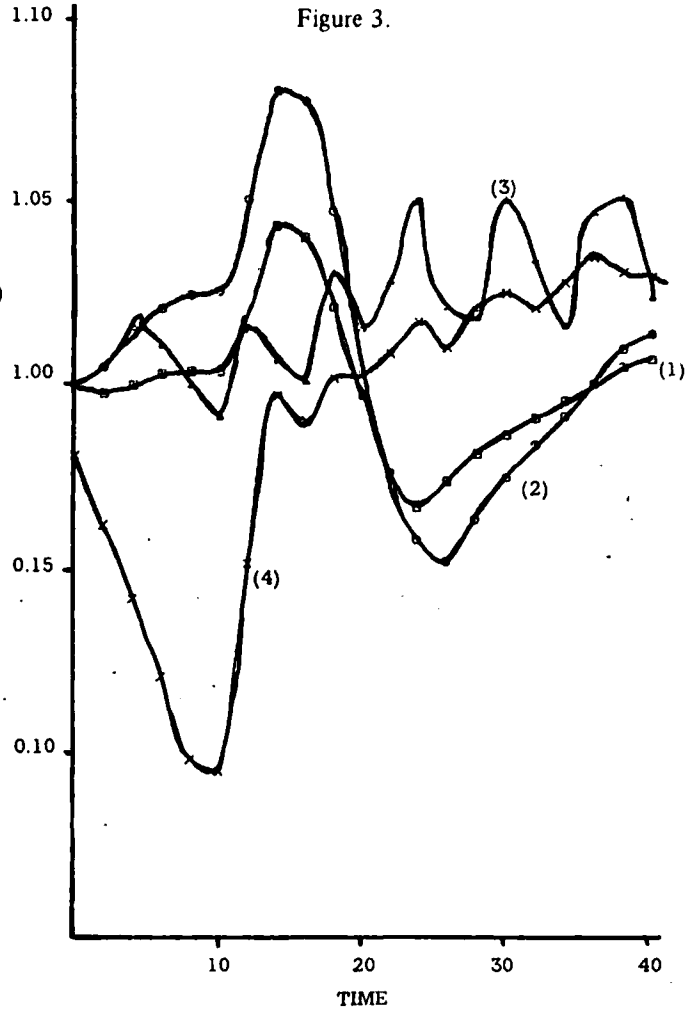
Several other scenarios have been generated and explored.

Figure 2.



PLVL – Year 12 school population (persons) (1)
UNDEMP – Number of graduates underemployed (persons) (2)
NUGU – Number of undergraduates at universities (persons) (3)
NHDU – Number of higher degree students at universities (persons) (4)
NUGC – Number of undergraduates at colleges (persons) (5)
NGDC – Number of graduate diploma students at colleges (persons) (6)

Figure 3.



CDAS – Community demand for academic skills (d'less) (1)
CDHS – Community demand for general higher education skills (d'less) (2)
CDTS – Community demand for technical skills (d'less) (3)
CDES – Community demand for education skills (d'less) (4)

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APPENDIX A (sample flow diagrams)

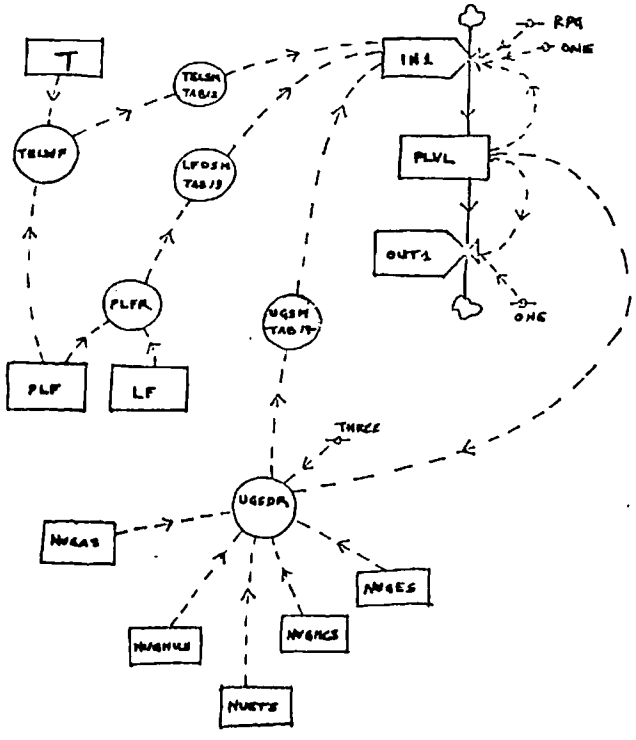

Figure 4: Flow diagram for year 12 secondary school enrolments.

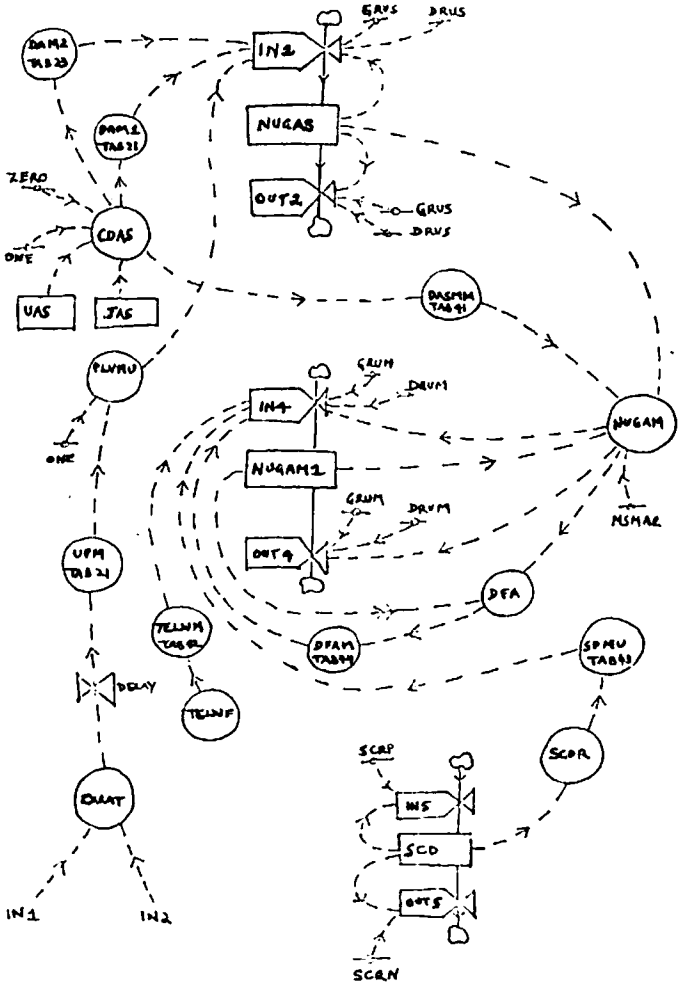

Figure 5: Flow diagram for academic course enrolment at Universities.

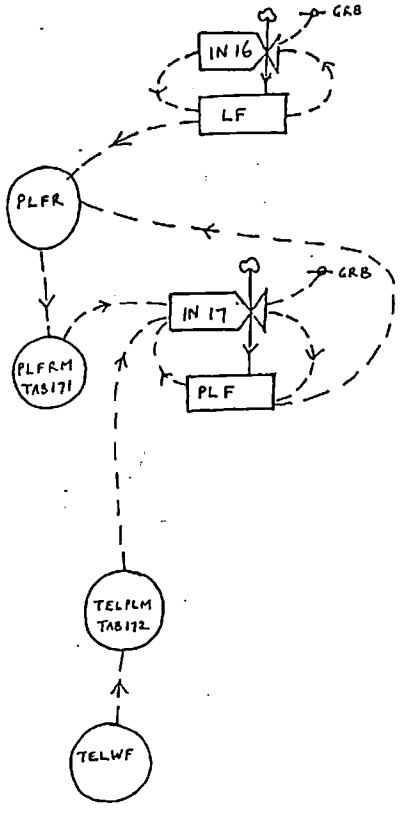

Figure 6: Flow diagram for labour force and professional labour force.

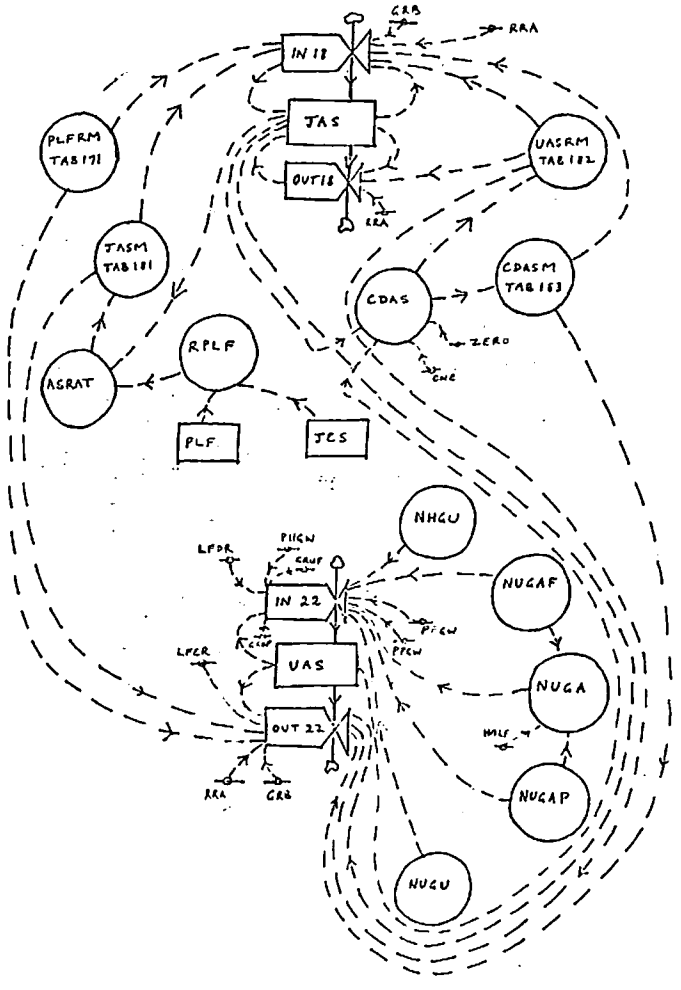

Figure 7: Flow diagram for jobs and unemployment – academic skills.

APPENDIX B

SYSTEM EQUATIONS (Sample)

The model building package used to develop the model was GRIPS. (Graphic Interactive Programming System). This package was designed by Dr. Walter Hudetz at the Frauhofer-Institut Fur Systemtechnik at Karlsrhue for use on a PDP11 and expanded at the University of Queensland where it is presently running on a VAX 11/780 system.

The model equations have been written in DYNAMO to facilitate communication. Because DYNAMO has been used for purposes of communicating model structure but not for obtaining model output a degree of licence has been taken in writing the equations.

(a) Table functions have been defined using the ordered pairs actually used to define the function (rather than in terms of equally spaced abscissae) as allowed by GRIPS.

(b) To conserve space the full details of equations involving the use of the CLIP function have been suppressed. To indicate those parameters which can be so changed the word CLIP has been inserted beside relevant definitions.

Year 12 School Population (PLVL)

PLVL is the system level variable that measures the population of students who are enrolled in the final year (12) of secondary school. Successful completion of this year means that a student is eligible for entry into university and college courses. In many faculties the student must compete for acceptance in a course quota which is usually determined by the degree of success achieved in the matriculation year.

```
L PLVL.K = KLVL.J + (DT) (INL.JK – OUTL.JK) N
PLVL     = PLVLI
C PLVLI  = 86,300
  PLVL   – population of year 12 in Australia (persons)
  PLVLI  – PLVL – initial value (persons)
  INL    – INTAKE TO PLVL (persons/yr)
  OUTL   – OUTPUT from PLVL (persons/yr)
R INL.KL = PLVL.K * (ONE + RPG.K) * TELSM.K *
           LFDSM.K * UGSM.K
ONE      – Since each year all of PLVL is dissipated the
           level in a new year is determined from
           replacement ± growth. ONE refers to the
           replacement of the previous year's enrol-
           ment.
```

RPG – rate of growth of the population of people of year 12 age in the community (fraction/year)
TELSM – tertiary educated level of the work force to school multiplier (dimensionless)
LFDSM – labour force distribution to school multiplier (dimensionless)
UGSM – undergraduate to school multiplier (dimensionless)

Rate of growth of population of year 12 age (RPG)

C ONE = 1.0
A RPG.K = TABHL (TAB11, TIME.K, 0, 60.0)
T TAB11 = .015, .015
TAB11 – RPG (exogenous) table function
RPG is entered as a table function to allow for continuous movements in population growth. In this formulation it is entered as a constant positive growth rate of 1.5% p.a.

Tertiary Educated Level of Work Force to School Multiplier (TELSM)

A TELSM.K = TABHL (TAB12, TELWF.K, 0, .5, .8, 1.0)
T TAB12 = 1.0, 1.0, 1.2, 1.2
TAB12 – TELSM multiplier table (dimensionless)
TELWF – Tertiary Educated Level of the Professional Work Force (dimensionless)
(Fraction of those employed in the professional labour force who hold a tertiary qualification).
A TELWF.K = T.K/PLF.K (dimensionless)
T – number in the professional labour force with tertiary qualifications (persons).
PLF – number employed in the professional labour force (persons).

Labour Force Distribution to School Multiplier (LFDSM)

A LFDSM.K = TABHL (TAB13, PLFR.K, 0, .11, .2, .3)
T TAB13 = 1.3, 1.0, .9, .8
TAB13 – LFDSM multiplier table (dimensionless)
PLFR – Professional Labour Force Ratio (dimensionless) (Ration of the Professional Labour Force to the total Labour Force).
A PLFR.K = PLF.K/LF.K (dimensionless)
PLF – number employed in the professional labour force (persons)
LF – number employed in the total labour force (persons).

Undergraduate to School Multiplier (UGSM)

A UGSM.K = TABHL (TAB14, UGSDR.K, 0, .3, .45, .7, 1.0)
T TAB14 = .5, .8, 1.0, 1.0, 1.2
TGSM – Undergraduate to School Multiplier (dimensionless)
TAB14 – UGSM multiplier table (dimensionless)
UGSDR – Undergraduates to School Density Ratio (dimensionless) (Ration of school-leaver undergraduates to 3 x year 12 enrolment).
A UGSDR.K = (NUGAS.K + NUGHUS.K + NUGTS.K + NUGHCS.K + NUGES.K)

THREE * PLVL.K

C THREE = 3.0
NUGAS – Number of undergraduates at University, enrolled from school, who are pursuing specific academic courses (persons)
NUGHUS – Number of undergraduates at University, enrolled from school, who are pursuing general higher education courses (persons)
NUGHTS – Number of undergraduates at colleges, enrolled from school, who are pursuing specific technical courses (persons)
NUGHCS – Number of undergraduates at colleges, enrolled from school, who are pursuing general higher education courses (persons)
NUGES – Number of undergraduates at colleges, enrolled from school, who are pursuing specific teacher training courses (persons)
R OUTL.KL = ONE * PLVL.K
The outrate for PLVL indicates that for each year the whole of the year 12 population leaves.

School leaver enrolment in undergraduate academic courses (NUGAS)

L NUGAS.K = NUGAS.J + (DT) (IN2.JK – OUT2.JK)
N NUGAS = NUGASI
C NUGASI 19800
NUGAS – number of school leavers enrolled in academic courses (persons)
NUGASI – NUGAS initial value (persons)
IN2 – inrate of NUGAS (persons/yr)
OUT2 – Outrate from NUGAS (persons/yr)
R IN2.KL = NUGAS.K * ERUS.K * PLMU.K * DAML.K 8 DAM2.K
ERUS – standard rate at which vacancies occur in the NUGAS population (fraction/yr)
PLVMU – PLVL to university multiplier (dimensionless)
DAM1 – labour force to academic course demand multiplier 1 (dimensionless)
DAM2 – labour force to academic course demand multiplier 2 (dimensionless)

Entry rate to university from school (ERUS)

A ERUS.K = GRUS + DRUG
(CLIP) GRUS – normal graduation rate for the school leaver under-graduate population (fraction/yr)
(CLIP) DRUS – normal discontinuation rate for the school leaver undergraduate population (fraction/yr)
C GRUS = .23
C DRUS = .07

PLVL to university multiplier (PLVMU)

A PLVMU.K = ONE + UPM.K
A UPM.K = DELAY (TABHL(TAB21, EXRAT.K, .7, 1, 1.3),DELI)
T TAB2 = .15, 0, .2
TAB21 – UPM multiplier table (dimensionless)
C ONE = 1
C DELI = 1
UPM – university policy multiplier (dimensionless)
DELI – length of delay (1 yr)
EXRAT – expansion rate of PLVL (dimensionless) (Ratio of Inrate ot PLVL/Outrate from PLVL)
A EXRAT.K = IN1, KL/OUT1.KL (dimensionless)

Labour force to academic course demand multiplier 1 (DAM1)

A DAM1.K = TABHL (TAB22, CDAS.K, 0, .5, 1, 2)
T TAB22 = .2, .25, 1
TAB22 – DAM1 multiplier table (dimensionless)
CDAS – Community Demand for Academic Skills (dimensionless) (This variable is defined in terms of the ratio of unemployed graduates to total number employed in jobs for which academic skills are required.
CDAS < 1 means unemployment exists
CDAS > 1 means that there is a shortage of graduate labour).
A CDAS.K = MAX (ONE – UAS.K), ZERO
JAS.K
UAS – unemployed graduates in the community with academic training (persons)
JAS – number of positions for persons with academic course training (persons).

Labour force to academic course demand multiplier 2 (DAM2)

A DAM2.K = TABHL(TAB23, CDAS.K, 0, 1, 1.1, 2)
T TAB23 = 1, 1, 1.4, 1.4
TAB23 – DAM2 multiplier table (dimensionless)
CDAS – community demand for academic skills (dimensionless)
R OUT2.KL = NUGAS.K * ERUS.K
The outrate for NUGAS is determined as the number of students leaving the system level either as graduates or discounting students.

Mature age enrolment in undergraduate academic courses (NUGAM)

For the flow diagram refer to Figure 5.

L NUGAM1.K = NUGAM1.J + (DT) (IN4.JK – OUT4.JK)
N NUGAM1 = NUGAM1
C NUGAM1 = 10,120
NUGAM1 – number of mature age undergraduates who would be enrolled in academic courses given sufficient places (persons)
NUGAM1 – NUGAM1 initial value (persons)
IN4 – inrate to NUGAM1 (persons/yr)
OUT4 – outrate from NUGAM1 (persons/yr)
R IN4.KL = NUGAM.K * ERUM.K * TELWUM.K * SDMU.K * DFAM.K
NUGAM – number of mature age undergraduates enrolled in academic courses. NUGAM1 is the population NUGAM together with other qualified aspirants (persons)
ERUM – standard rate at which vacancies occur in the NUGAM, (NUGAM1) population (fraction/yr)
TELWUM – TELWF to university mature entry multi-plier (dimensionless)
SDMU – social demand to university mature age entry multiplier (dimensionless)
DFAM – disappointment fraction to academic mature age entry multiplier (dimensionless).

Entry rate of university from mature age undergraduates (ERUM)

A ERUM.K = GRUM + DRUM
(CLIP) – normal graduation rate for mature age population (fraction/yr)
GRUM
(CLIP) – normal discontinuation rate for mature age population (fraction/yr)
DRUM
C GRUM = .15,
C DRUM = .10

Mature age undergraduates enrolled in academic courses (NUGAM)

A NUGAM.K = MIN NUGAS.K * MSMAR * DASMM.K),
NUGAM1.K
MSMAR – mature age – school leaver minimum academic ratio (dimensionless)
This value is set permanently at 0.25 which means that the ratio of mature age students to school leavers is assigned a minimum arbitrary value of ¼. (The choice is arbitrary apart from the need to provide a lower bound for all simulation runs).
DASMM – demand for academic skills to mature age policy multiplier (dimensionless)
C MSMAR = 0.25

Demand for academic skills – mature age policy multiplier (DASMM)

A DASMM.K = TABHL (TAB41, CDAS.K, 0, .8, .9, 1, 2)
T TAB41 = 1, 1, 4, 6, 6
TAB41 – DASMM multiplier table (dimensionless)
CDAS – community demand for academic skills (dimensionless)
The multiplier values can be varied to represent various policies with respect to mature age – school leaver student balance. For example setting all table values at 1000 would enable mature age enrolment to grow uninhibited to 250 times the corresponding school leaver enrolment. This is equivalent to allowing unlimited growth.

Tertiary Educated Level of Labour Force to mature age university multiplier (TELWUM)

A TELWUM.K = TABHL (TAB42, TELWF.K, 0, .1, .7, 1)
T TAB42 = 1, 1, 1.3, 1.6
TAB42 – TELWUM multiplier table (dimensionless)
TELWF – tertiary educated level of the professional labour force (dimensionless)

Social conditions to mature age university multiplier (SDMU)

A SDMU.K = TABHL (TAB43, SCDR.K, 0, 1, 3, 5)
T TAB43 = 1, 1.1, 1.2, 1.2
TAB43 – SDMU multiplier table (dimensionless)
SCDR – social conditions ration (dimensionless)
A SCDR.K = SCD.K/SCDI
SCDR – social conditions ratio (dimensionless)
SCD – social conditions (social conditions units)
SCDI – SCD initial value (social conditions units)
This value is arbitrarily set to 1.
L SCD.K = SCD.J + (DT) (IN5.JK – OUT5.JK)
N SCD = SCDI
C SCDI = 1
IN5 – inrate to SCD (social conditions units/yr) – a measure of the rate of increase of complexity of society.
OUT5 – outrate from SCD (social conditions units/yr) – a measure of rate of decrease of complexity of society. (Not relevant in the

```
                present formulation in which complexity
                is assumed to be increasing)
R IN5.KL        = SCD.K * SCRP
  (CLIP)        - assumed percentage growth rate of social
  SCRP            complexity (fraction/yr)
C SCRP          = .02
R OUT5.KL       = SCD * SCRN
  (CLIP)        - average percentage rate of decrease of
  SCRN            social complexity (fraction/yr)
C SCRN          = 0
A DFAM.K        = TABHL (TAB44, DFA.K, 0, .5, .8, 1)
T TAB44         = 1, .6, .25, .25
  TAB44         - DFAM multiplier table (dimensionless)
  DFA           - disappointment fraction academic course
                  (dimensionless).
A DFA.K         = (NUGAM1.K - NUGAM.K)/NUGAM1.K
R OUT4.KL       = NUGAM.K * ERUM.K
```