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A LIFE-CYCLE MODEL OF CAREER EXPERIENCE: THE AMERICAN ACADEMIC LABOUR FORCE

Tony Cornford

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INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

THE AUTHOR

Tony CORNFORD is with the Centre for Labour Economics, London School of Economics, Houghton Street, London, WC2A 2AE, England.

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Abstract

The paper presents a deterministic simulation of career experience in the American university labour force. The model is used to investigate the difference in career experience for entrants to the profession in the years from 1962 to 1978, taking into account the size, structure and age distribution of the profession, as well as the relative ability of entrants. An investigation is also made of the effects of various retirement policies.

The results of the study show that there will be a considerable difference in career advancement for people starting during this time period. The average person entering the profession in the early 1960s can in general expect to reach the rank of associate professor roughly 5 years earlier than his colleague entering 10 years later. The results also show the clear and substantial role of ability in determining the career profile. 1970s entrants of high ability start their careers with considerable delay, but after 20 years experience they are relatively less delayed, reaching a full professorship only 2 years later than their older colleagues.

An investigation of retirement policies, both to prolong working life and to shorten it, shows that people in the profession in their first twenty or thirty years have little to fear or gain from such policies. The effect in either case is of very small magnitude and is far outweighed by the temporal effects, themselves the result of growth policies and the age distribution of the profession members.

1. Introduction

As the baby boom of the 1940s and 1950s moves through the institutions of our society, it leaves its mark. The rise and fall of the record industry is one example, others are the expansion and subsequent contraction of secondary education or the expansion of maternity services to care for the boom babies' babies. The investigation of these demographic and economic processes is a complex and relatively unexplored area, often with an unclear causality.

One major area in which large cohorts will have their effect is the labour market. The effects can be measured in terms of the salaries the boom cohort can expect, as in Welch [7]. This paper, however, looks at the labour market from a slightly different perspective, considering careers from the viewpoint of individuals, where a career is the progression through the hierarchy of a profession.

A model is used which describes the career life cycle of an individual within a profession in which progress through the hierarchy is determined by the individual's ability as well as the size, age distribution and hierarchy or rank structure of the profession.

A case study is presented, based on the American academic labour force, considering the careers of entrants from 1962 to 1978. The university teaching profession is used here as an example of the type of profession, subject to clear and specific demographic effects and in which the ability of a member is a principle determinant of progress. Universities expand to accommodate large cohorts. This expansion draws in larger numbers of teachers. It is the careers of these people, drawn into the profession that this paper is looking at.

This life cycle approach contrasts with that used by most authors on manpower planning who adopt a view which looks at the problem from the point of view of the organisation rather than that of the individual. Bartholomew and Forbes [2] in summarising the work on Kennay, Ray and Morgan [5] show how an age bulge in recruits will affect, over time, the age of promotion in a fixed proportion hierarchy of jobs, or the proportion promoted for a fixed age-at-promotion system, but these results still appear as organisational aggregates, not individual life histories; they also take no account of ability.

The goal in this paper is to look at 3 issues connected with career life cycles of university teachers. The first is that of inter-temporal inequality of careers, how people entering the profession at different times will experience different career profiles.

The second issue is the role of ability in determining the shape of a career, and how exactly ability is to be defined. The third issue is the effect of retirement policies on younger members of the profession.

In Section 2 the model of Arthur [1] is presented. In Section 3 the data used is described and Section 4 contains the results.

2. The Model

Arthur's model [1], used here, considers the career path of an individual as being determined by two separate mechanisms:

(a) the size and structure of the profession, and

(b) the number of people within the profession who are considered to be superior to the individual by the mechanism which assigns jobs (i.e. the position within a ranking of all members of the profession).

By evaluating (b) and fitting it to (a), both over time, it is possible to chart the career of an individual within the organisational structure.

A simple theoretical model, using the concepts outlined above, might take the following form. In this simple model the ranking is assumed to be done simply by age. Older people are always senior.

(A) Positions

At time t the number of positions above level α in the hierarchy is $M(\alpha,t)$, given by the integral from α to $\bar{s}$ (the highest position) of $m(s,t)$, where $m(s,t)$, is the number of jobs at level s at time t. Thus

$$M(\alpha,t) = \int_{\alpha}^{\bar{s}} m(s,t)\, ds \qquad (1)$$

(B) <u>People</u>

The career of person R, born in year t_R is under investigation. The number of people above R in the ranking at time t is N(t), given by

$$N(t) = \int_{t-90}^{t_R} L(x)\, p(x,t)\, dx \qquad (2)$$

L(x) = number of entrants to the profession born in year x.

p(x,t) = probability that entrant born in year x survives to year t.

(Using t-90 as the lower limit implies only that the maximum age of a person in the profession is 90.)

The position of the person, R, at time t is then given by the accounting identity

$$M(\alpha,t) \equiv N(t) \qquad (3)$$

This says that all people preferred to R are in positions above R. In this case these people are all those older than R. The level occupied by R is therefore the α that satisfied the identity.

With such a model each entrant will start at the bottom and eventually reach the top, assuming he starts at the youngest age possible and survives to the end. With a slight change to this simple formulation the ranking factor could be changed from age to time-in or experience.

A sophistication clearly needed is to take account of the real nature of the world, in which factors other than age determine careers. To implement this it is necessary to add some dimension other than age in evaluating the ranking of people. For the work reported here one other variable is used, and referred to as 'non age factors', or NAF. If one wishes to give it a more common name one could say 'ability', but this word might have too strong connotations for the rather nebulous variable we need.

What NAF is intended to represent is a set of characteristics of an individual which are not changing over time, and which affect his position in the ranking of individuals. For example, in the academic system such non age factors will include intellectual ability and ingenuity as well as good looks, paper-publishing ability and the university from which one graduated. This NAF measure is intended to capture all these aspects.

By setting up an iso-preference schedule it is possible to represent the organisation's trade-off, in filling jobs, between age and the NAF measure. If persons A and B in Figure 1 are considered by the organisation to be equally placed in the organisational ranking, then we consider that they lie on the same iso-preference curve.

Furthermore, if we assume a set of iso-preference curves with the general shape shown in Figure 2, and represent the time paths of persons A and B by horizontal vectors, then it is possible for person A to make a greater gain in the ranking over a period h than his colleague B who has lower NAF. Indeed by shifting A's path a little to the left it is possible for him to start out behind B and finish in front of B in the ranking. This is an example of a younger man overtaking an older one.

If we consider a third dimension to Figure 2, showing the density of people at given (age, NAF) points, then it is possible to translate this into an integral equation to replace equation (2).

If person R has NAF $\bar{i}_R$ then at time $\bar{t}$ he will lie on some iso-preference curve which we can represent by the function

$$i = \emptyset(t,\bar{t},\bar{i}_R) \tag{4}$$

The number of people preferred to R at time t,N(t),are those that lie to the right and above the curve defined by (4). N(t) is then given by the double integral.

$$N(t) = \int_{T} \int_{i = \emptyset(t,\bar{t},\bar{i}_R)}^{m} L(\bar{t}-t)p(\bar{t}-t,t)\ dx\ dt \tag{5}$$

Figure I : An Iso-preference curve

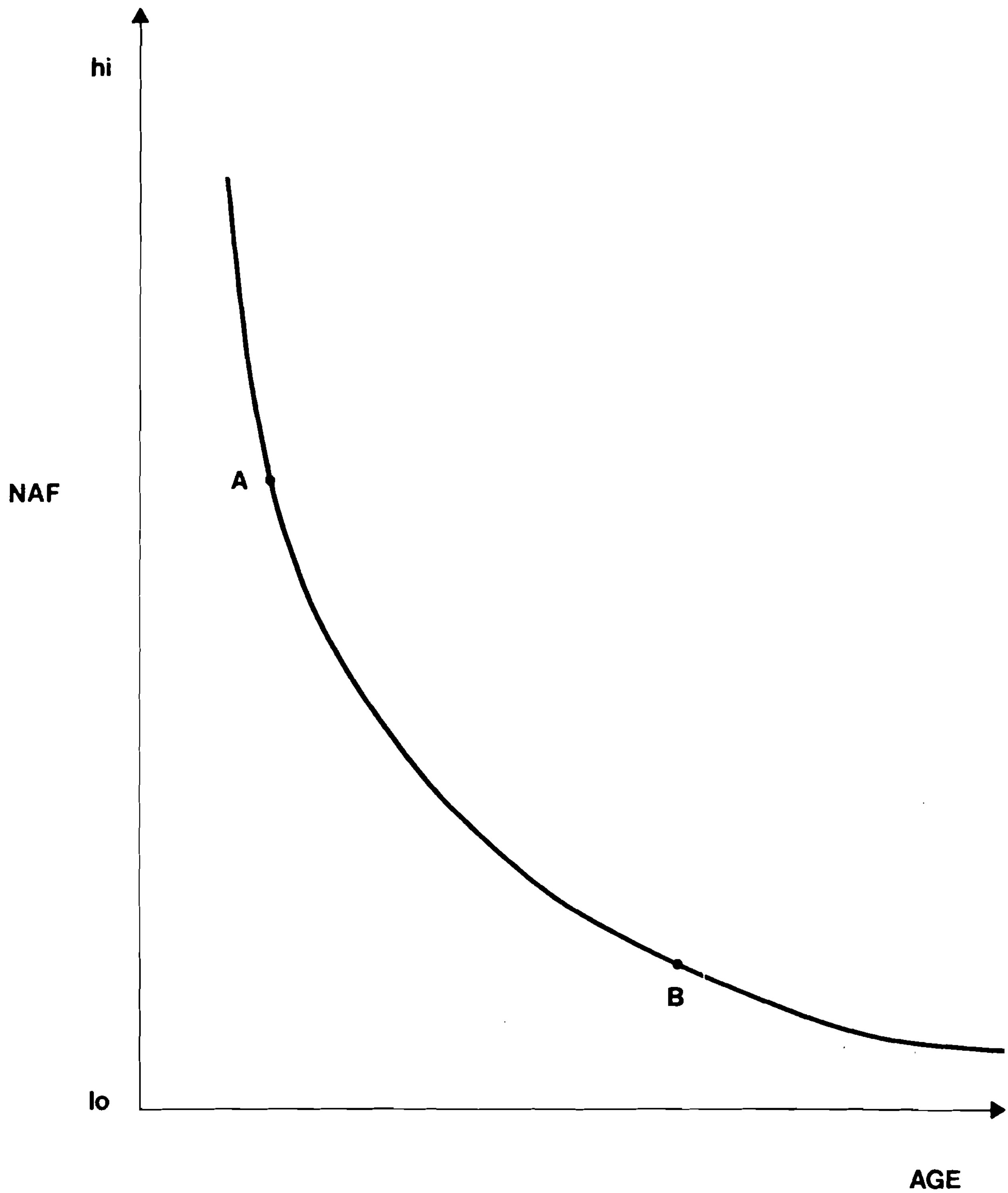
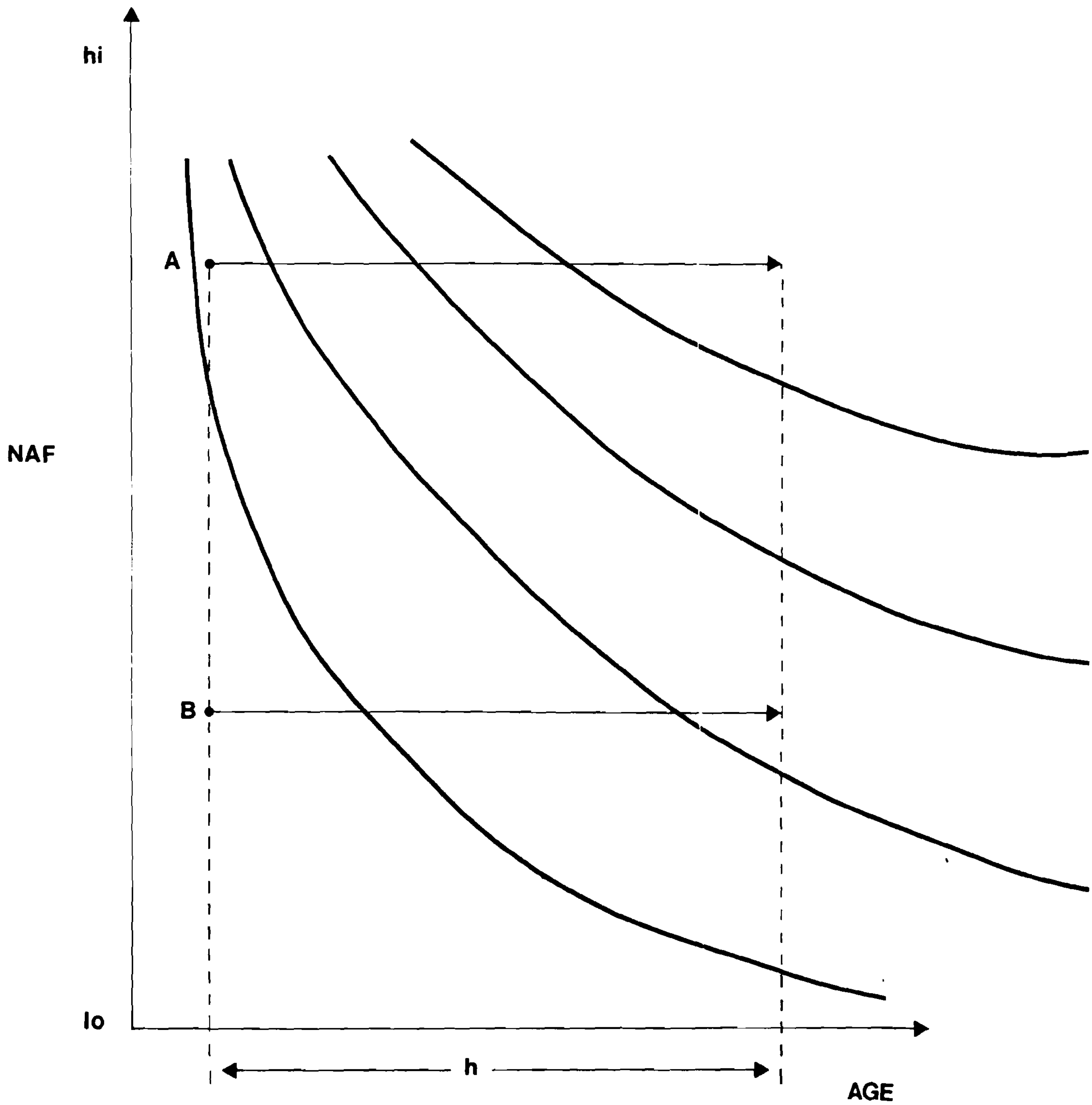


Figure 2 : Effect of time passing on relative position



m = highest NAF possible.

Data has been fitted to this version of the model, allowing age and NAF's to determine rank position.

3. Data

The data used for this model are taken from Cartter [3]. The data he presents are in the context of his own study, which concentrated principally on demand for graduating Ph.Ds. The figures are not always in the most appropriate form for the model used here.

The data required to run the model are as follows:

(A) Data on size and structure of the American academic employment sector over time.

Cartter [3] gives actual data on the size of the sector for 1962 to 1972, and projections for 1973 to 1990. The figures he presents are already processed to represent full-time equivalent staff. See Table 2.

For structure, the figures used are the proportion of the profession in the four grades in 1972, see Table 1.

(B) Data on mortality and retirement patterns.

Cartter's figures are shown in Table 3, together with a comparable set of pure mortality figures.

(C) Data on the ages of new entrants to the profession.

These will naturally change from year to year with market conditions etc. The figures used are shown in Table 3.

(D) An estimate of the iso-preference schedule.

This is a more complex problem. The starting point is Table 4. From this table the cumulative percentages within age groups are computed for each of the 4 grades, Table 5.

This information can be plotted in a graphical form as in Figure 3. In Figure 3 the vertical axis on the left is labelled as cumulative percent, and the figure is seen to represent the data of Tables 4 and 5.

TABLE 1

Rank structure (1972)

	Number	% above
Full Professor	121,065	0.0
Associate Professor	115,005	31.5
Assistant Professor	117,705	61.5
Instructor	30,220	92.1
	383,995	

TABLE 2

Size of academic labour force (000's)

Actual

1962	173
63	184
64	212
65	248
66	278
67	299
68	331
69	349
70	368
71	379
72	384

Projected

1973	392
74	397
75	406
76	416
77	426
78	435
79	447
80	457
81	463
82	465
83	463
84	458
85	449
86	440
87	438
88	439
89	442
90	437

Notes: (1) All figures from Cartter [3].
(2) Projected figures on the basis of 17:1 incremental faculty ratio.

TABLE 3

Age distribution of faculty entering and leaving higher education (in percentages)

Age group	Entrants from other employment (1)	Entrants with doctorate from graduate school (2)	Entrants without doctorate from graduate school (3)	Experienced out-migrants (4)	Mortality and retirement rate (5)	Annualised U.S. Male Life table 1964 (6)
30 and under	20	44	49	20	0.16	.18
31 - 35	33	29	35	28	0.18	.22
36 - 40	17	14	9	24	0.28	.30
41 - 45	14	8	8	15	0.44	.47
46 - 50	8	4	1	7	0.69	.75
51 - 55	4	1	0	4	1.07	1.20
56 - 60	3	0	0	1	1.66	1.87
61 - 65	1	0	0	1	6.53	2.78
Over 65	0	0	0	0	33.74	4.19
	100	100	100	100		

Source: Cols. (1)-(5), taken from Cartter /3/.
Col. (6), calculated from Keyfitz and Flieger /5/.

Notes: (1) For this study the figures from Col. (2) have been used to describe age of entrants.
(2) Differences between Cols. (5) and (6) are due to the presence of women and the academic sub-population.

TABLE 4

Age, rank, and tenure distribution of faculty, 1972

Age group	Faculty total		Professor		Associate professor		Assistant professor		Instructor or other		Faculty with tenure	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
30 and under	27,650	7.2	130	0.1	1,350	1.2	16,800	14.3	9,370	31.0	5,845	2.2
31–35	68,355	17.8	1,155	1.0	17,445	15.2	41,145	34.9	8,610	28.5	25,760	9.7
36–40	65,665	17.1	8,315	7.0	29,275	25.4	24,350	20.7	3,730	12.3	42,785	16.1
41–45	62,590	16.3	20,215	16.7	26,250	22.8	13,540	11.5	2,585	8.5	49,690	18.7
46–50	53,760	14.0	26,175	21.6	16,220	14.1	9,015	7.7	2,345	7.8	46,240	17.4
51–55	44,930	11.7	25,605	21.1	12,055	10.5	5,820	4.9	1,445	4.8	40,125	15.1
56–60	31,870	8.3	19,300	15.9	7,175	6.2	4,210	3.6	1,185	3.9	28,700	10.8
61–65	21,500	5.6	14,340	11.8	4,120	3.6	2,405	2.0	640	2.1	19,665	7.4
Over 65	7,680	2.0	5,830	4.8	1,115	1.0	420	0.4	320	1.1	6,910	2.6
TOTAL	384,000	100	121,065	100	115,005	100	117,705	100	30,220	100	265,730	100

Source: Taken from Carttier [3].

TABLE 5

Cumulative rank distribution of faculty, by age group

Age Group	Full Professor	Associate Professor	Assistant Professor	Instructor
-30	0.00	0.05	0.66	1.00
31-35	0.08	0.27	0.87	1.00
36-40	0.13	0.57	0.94	1.00
41-45	0.32	0.74	0.96	1.00
46-50	0.49	0.79	0.96	1.00
51-55	0.57	0.84	0.97	1.00
56-60	0.61	0.83	0.96	1.00
61-65	0.67	0.86	0.97	1.00
66 +	0.76	0.98	0.96	1.00

Figure 3 : Percentage of age group above given levels, 1972

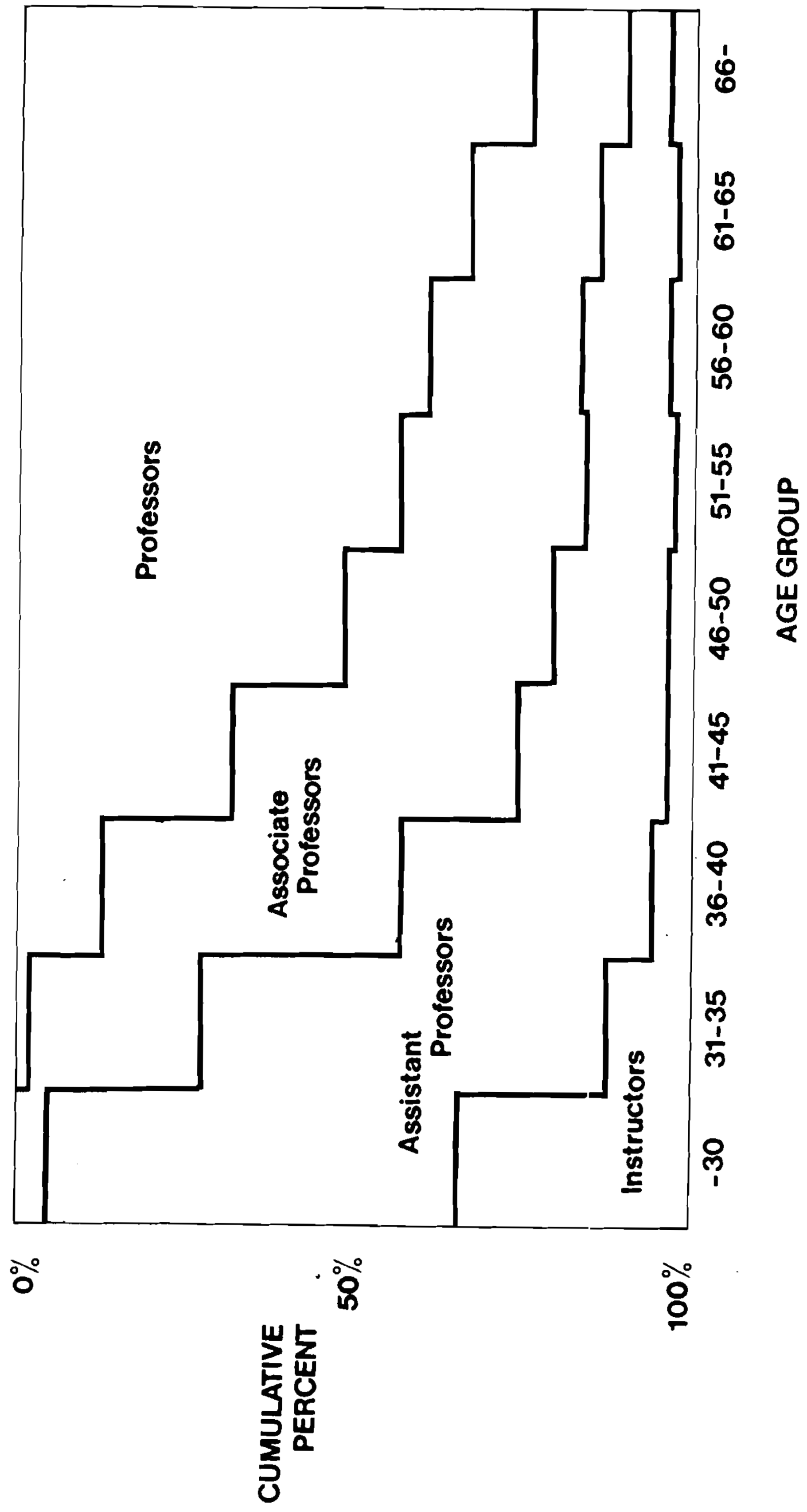


Figure 3 is in fact a CAMMERA diagram [2,6], a method of presenting a snapshot of the grade-age distribution. Bartholomew & Forbes [2] make use of such a diagram to identify streams of employees within an organisation, subject to some assumptions of stationarity.

The diagram can be used to predict if it is interpreted as a grade-age blueprint for the profession for all time, but this, as Bartholomew and Forbes admit, is too strong an assumption. The model of Arthur [1] used here takes the CAMMERA diagram one stage further. Though it is a strong assumption to use the diagram as a grade-age blueprint for the profession, it is much less restrictive to use it as an estimate of the preference system used by the organisation under consideration.

The step function between, say, assistant and associate professor can be thought of as not only representing the actual boundary between the two grades in 1972, but also as representing one of the iso-preference curves of the institutional mechanisms which determine careers in American universities. The curve represents the trade-off between age and non-age factors.

Since this model is deterministic, and since it follows one individual through his career, his NAF measure is an input parameter. Further, if we always express NAF's as a position in a ranking, i.e. as the percentage of people, within his own age group, above a person under consideration, then the exact distribution need never be considered.

To describe an individual as a 20% person implies that 20% of his peers are considered to be better endowed with NAF than he is, regardless of the distribution of NAF. The only assumption is that NAF is similarly distributed in all age groups at all times considered.

Within the computer model we need more than the three iso-preference curves shown in Figure 3 and an age scale finer than 5-year age groups. The procedure followed is:

(i) Bumps are removed from the curves in Figure 3. In fact only slight bumps are present.

(ii) The curves are smoothed, piecewise linear midpoint to point, to allow a different percentage above for each year age group.

(iii) A schedule of lines is considered to exist between the lines on the figures, lying always proportionately within the vertical gap.

The model requires, for each year, an age distribution of people in the profession (i.e. a density of people on Figure 1 or 2). With this information and the (age, NAF) point of the person under investigation, it is possible to evaluate the number of people above in the ranking.

Since the age distribution is the key to this process, the evaluation of the number of persons in front of R is preceded by a simple demographic model which calculates the age distribution for the year.

For year t in age group a, there are X_{ta} persons, where

$$X_{ta} = X_{t-1a-1}\, p(a-1) + R_t\, q(a)$$

p(x) = Probability an individual survives year x (i.e. does not retire or die, Col. 5, Table 3).

R_t = Number of individuals added to the system between year t-1 and year t. These people might be for replacement of leavers or for growth.

q(a) = Probability that a new entrant is of age a (Col. 2, Table 3).

Cartter [3] publishes data on the age distributions for various years. Table 6 compares his figures with those from this simple model.

In each year for each age group the iso-preference line occupied by R, the person under consideration, will cross at some point on the cumulative percentage NAF scale. The number preferred to R in each age group is given by multiplying this percentage by the number of people in that age group.

TABLE 6

Age distributions

Age Group	Actual 1962	Actual 1968	Model 1968	Actual 1972	Model 1972
-30	10.3	15.4	12.8	7.2	5.8
31-35	15.7	17.0	23.3	17.8	20.1
36-40	17.8	16.4	18.6	17.1	22.9
41-45	15.7	14.4	14.6	16.3	16.9
46-50	13.6	12.9	11.2	14.0	13.0
51-55	10.5	9.6	8.2	11.7	9.2
56-60	7.9	6.8	5.6	8.3	6.3
61-65	5.6	5.3	3.6	5.6	3.8
66 +	2.9	2.2	2.0	2.0	2.0

4. Results

The effect of ability on the career

Figure 4 shows the model's simulated career paths for individuals who entered the academic labour force in 1962, aged 25-26. It shows the projected paths for individuals 20, 50 and 80% of the way down the NAF ranking.

The best individual, (20%), achieves a full professorship in 1977, at age 40-41, while the median individual achieves and associate professorship in 1974, at age 38, 8 years after his colleague with higher NAF.

Also shown on this diagram, for contrast, is the path of an individual if all promotion is done by age. Notice the clear differences between this path and that of the median person under the NAF scheme. When promotion is done on the basis of age then all people will start at the bottom of the hierarchy and rise to the top, subject only to staying alive. The effect of including ability in the promotion system is to 'flatten' the career of all people.

This graph shows the way in which this model captures in a purely deterministic way the differences in ability of individuals, and how ability defines an individual's career to a substantial extent.

The inter-temporal effects on the career

Figure 5 compares the predicted career paths of high ability individuals entering in various years. The general trend is that those who started earlier achieved key hurdles in their careers after less time, but note the good starting positions of a 1968 entrant who derives initial benefit from the very fast expansion of the period, but whose career slows down when expansion stops.

The differences in the paths might be explained in two ways. Either the differences are due to the different age profiles in the profession faced by the entrants, or they are due to the different growth profiles of the profession faced by the entrants. In general the second explanation is more plausible. Note from Table 6 that the age structures faced by 1962 and 1972 are broadly similar, while their careers are not. Notice also the closing of the gap for all these people as time passes.

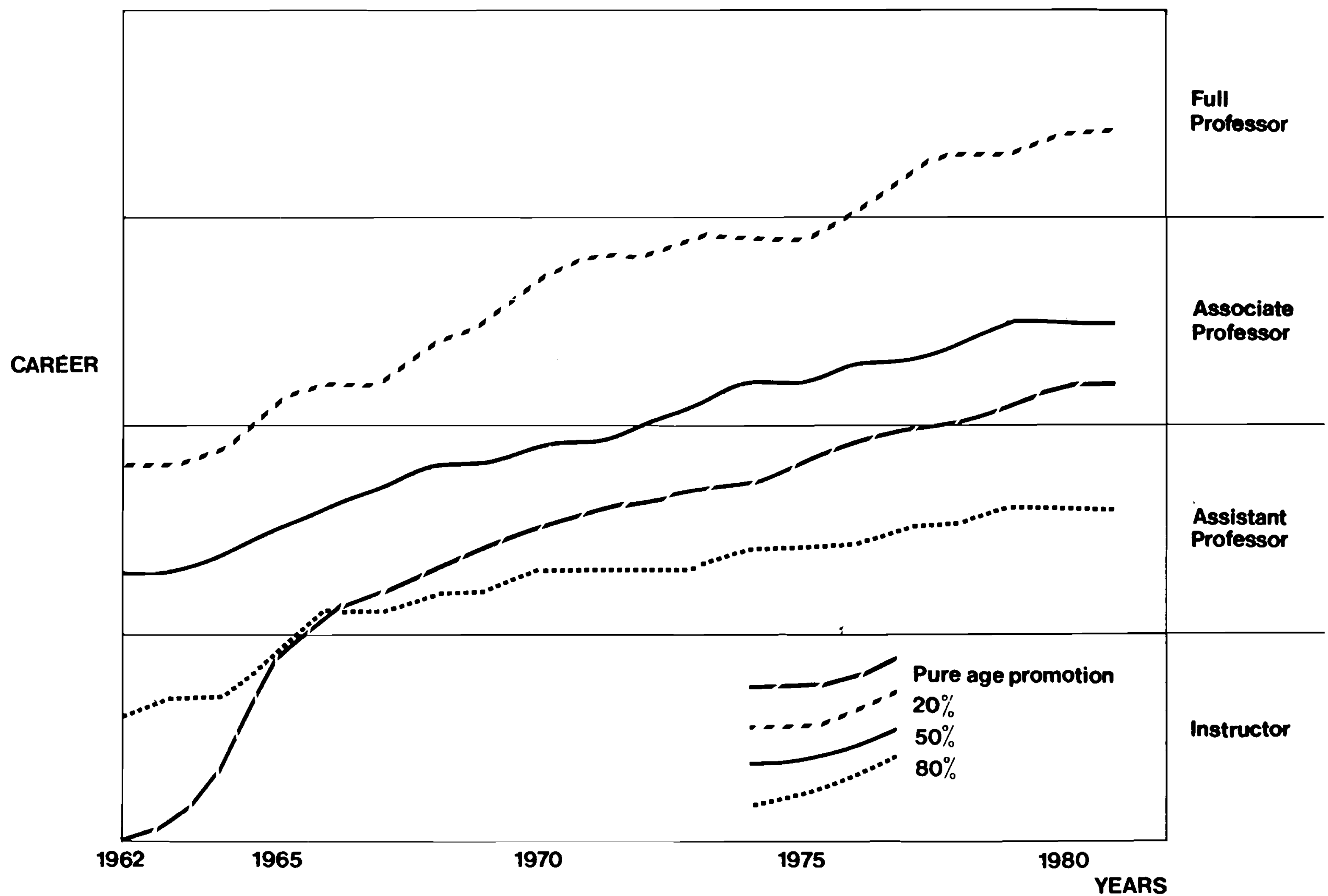


Figure 4 : Career profiles for entrants in 1962

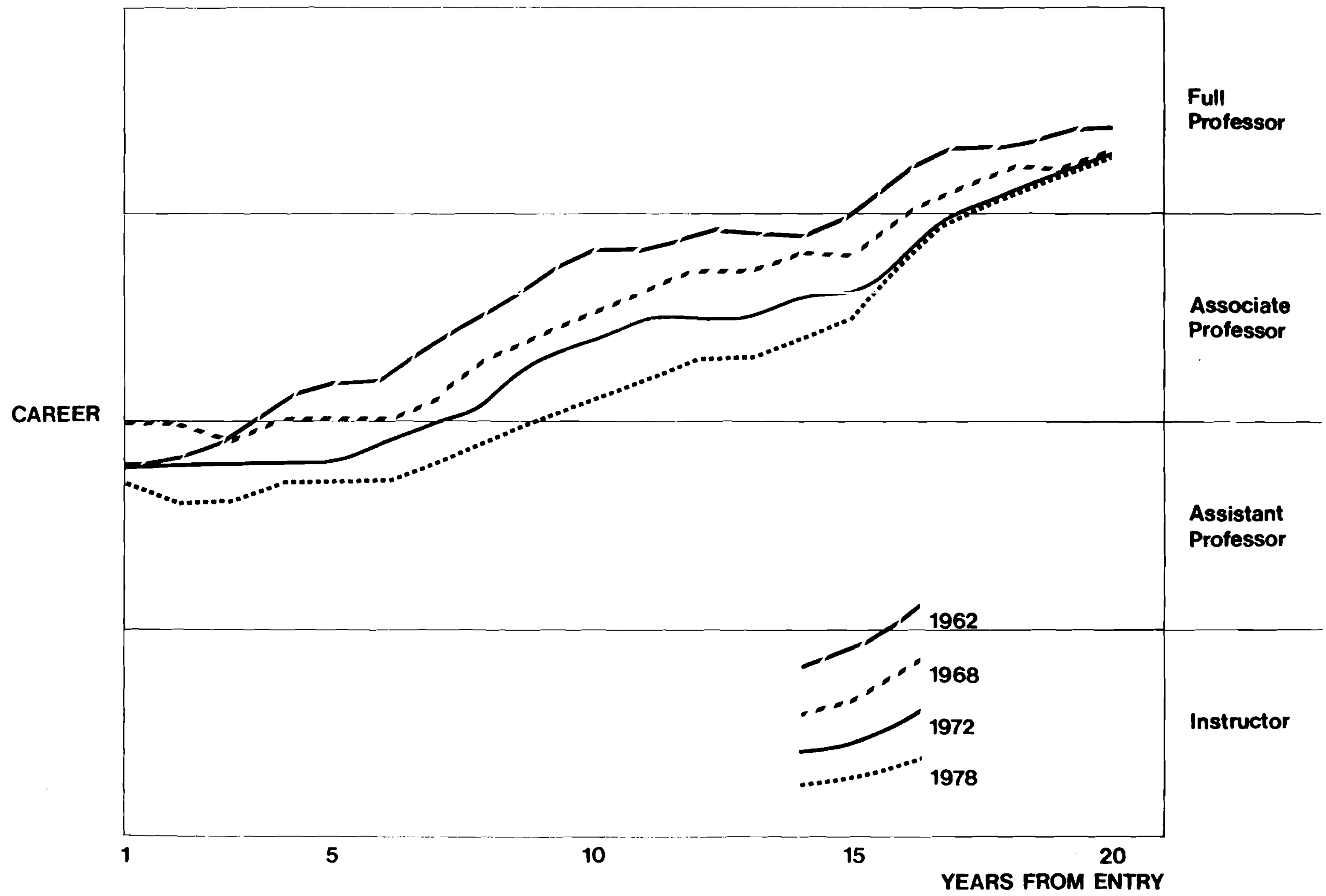


Figure 5 : Career profiles for 20th percentile entrants

Table 7 shows the length of time taken to achieve an associate or full professorship for these 20 per cent people over a range of years. The gap for the associateship, as between the worst year of entry and the best is 6 years, while for the full professorship it narrows to 2 years. This demonstrates a key feature of this model. The people of high ability, even those in the worst age group, can expect a fairly equal position in the hierarchy after 20 years. Their ability will help them to overtake any large groups ahead of them. For the median people in Table 7 the situation is not so good. Without high NAF's they can not overtake obstacles in their way. After the period of time when the 20% people are starting to lose their inequality, the 50% people are still facing a very wide gap of 8 years.

The effect of retirement policies

The retirement problem is currently of considerable interest in a number of countries. On the one hand, people concerned with unemployment and the problems of new entrants to the labour force look to earlier retirement as a policy. On the other hand, particularly in the U.S.A., a movement to prolong the working life is gaining ground, even finding its way into the law.

The model shows that the effect of these policies on the first 20 years of working life is very small. For instance, if one simulates the first 20 years of a 1968 entrant under a variety of retirement policies, including compulsory retirement at 62, 65 or 70, as well as the 'normal' system of most retirement between 60 and 65, the model produces exactly the same figure - 12 years - for transfer from Assistant Professor to Associate Professor. Over the whole 20-year period the advance or delay resulting from the policies is at most one year.

This is not, of course, the only way to look at retirement. We do not consider if more people will be hired, or if the salary bill of an institution will be reduced. This model simply looks at the policy from the point of view of a member of the profession who has a job. Even studies that do consider the points above, such as Hopkins [4] conclude that effects are not on a grand scale, particularly long-run effects. Hopkins does show a substantial short-

TABLE 7

Number of years taken to cross certain career hurdles

20% Individual		
Year of entry	Associate Professorship	Full Professorship
1962	3	15
1968	6	16
1972	7	17
1978	9	17
50% Individual		
1962	11	
1968	13	
1972	16	
1978	17	

run rise in the appointment rate, as does this model, but that is not the same as a substantial improvement in careers.

5. Conclusions

This paper puts forward a model of a career that allows analysis of the actual experience of individuals at different points in time, and of individuals with differing characteristics or ability. This model can be used with quite modest data, of a type available for many professions and occupations.

While it does not, at least in this simple exposition, directly address the usual issues of labour economics such as earning power and labour supply, it does, as the results presented here show, allow an equally important set of labour market characteristics to be analysed.

References

1. Arthur, W.B., 'Age and Earnings in the Labour Market: Implications of the 1980's Labour Bulge', WP-79-118, IIASA, Austria, (1979).

2. Bartholomew, D.J. and Forbes, A.F., Statistical Techniques for Manpower Planning, Wiley, London, (1979).

3. Cartter, A.M., Ph.Ds and the Academic Labour Market, McGraw Hill, New York, (1976).

4. Hopkins, D.S., 'Faculty Early-Retirement Programs,' Operations Research, Vol. 22, pp.433-467, (1974).

5. Keyfitz, N. and Flieger, W., World Population, University of Chicago Press, Chicago, (1973).

6. Morgan, R.W., Kennay, G.A. and Ray, K.H., 'A Steady State Model for Career Planning' in D.C. Clough, C.G. Lewis and A.L. Oliver (eds.) Manpower Planning Models, English Universities Press, London, (1974).

7. Welch, F., 'Effects of Cohort Size on Earnings: The Baby Boom Babies' Financial Bust', Journal of Political Economy, Vol. 87, No. 5, Part 2, pp.S65-97, October, (1979).