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1. S.M. Goyal, W.N. Adams, M.L. O'Malley and D.W. Lear, 'Human pathogenic viruses at sewage sludge disposal sites in the Middle Atlantic Region', *Applied and Environmental Microbiology*, 48, 4, 1984, pp. 758-63.

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Professional Engineers in Australia: Population Analysis *by Michael R. Rice and Brian E. Lloyd*
(Engineering Labour Force Series No. 2, EPM Consulting Group, in association with the Institution of Engineers, Australia, and the Association of Professional Engineers, Australia, 1990), pp. x + 86, $A45.00, ISBN 0-646-00759-9.

This book provides a statistical history of the professional engineering labour force in Australia from 1850 to 1990. Its principal objectives are to quantify in a detailed and accurate way this sector of the Australian labour force in each year since 1850, taking into account factors such as education, migration, retirement and other depletions, and to analyse it quantitatively with regard to disciplines, age distribution and employment sectors.

Authors Rice and Lloyd and their consulting group are well-known in Australia for researching, writing and commentating on engineering education and on the engineering profession over many years.[1] This particular book is the second in a series on the engineering labour force which they and their colleagues are preparing.[2] One of its secondary objectives is to lay the groundwork for a later book in this series which will look at professional engineers in an international context. It is also intended to provide a reliable foundation for policy and further research affecting the engineering profession.

The authors make the distinction between the *professional engineering labour force* — that is, the total number of people in the population with professional engineering qualifications and under the retirement age of 65, regardless of their employment function, and the *professional engineering stock,* that is, the sub-set of the PE labour force who are actively connected with engineering. They point out that at the beginning of 1990 there were around 90,000 professional engineers in the labour force in Australia. The stock figure, however, was approximately 78,000.

The book begins with a section giving a very brief summary and the main conclusions. Its five chapters begin with an introductory one which lays the groundwork for the analysis that is to follow. The next two deal with the periods 1850-1920 and 1920-1989. The fourth discusses engineering disciplines and functions during the period 1978-1987, and the last one deals with the distribution of engineers by state.

The year 1850 was chosen for the beginning of the study since, prior to the Gold Rushes that began in 1851, there had been little demand for engineering services. The division of the period of the study at 1920 — which just happens to be half way between 1850 and 1990 — was in practical terms determined by the establishment of the Institution of Engineers, Australia in 1919 and by the fact that this led to the formalising of the definition of a 'professional engineer'. Prior to this, the word 'engineer' meant a person engaged in professional engineering and fulfilling the accepted contemporary criteria of

a 'professional'. Also prior to 1920, not all of the engineers in Australia had received a formal professional education, many served as pupils or apprentices to recognised professionals and engineering firms. The authors point out, however, that not all who qualified to be counted as professional engineers in the period after 1920 did, in fact, belong to the Institution.

The statistics available for the earliest years of the study are sparse, leaving the authors no choice but to make a number of assumptions. This they have done with care, checking the plausibility of their estimates for specific years from such complementary data as are available. They start the whole exercise off, for example, by assuming an engineering labour force of 50 for 1850, and that all of them entered through the pupil/apprentice route. They only factor in immigraton from 1855 onwards. The statistical picture brightens somewhat in 1866 when the University of Melbourne began formal education in engineering, to be followed by the University of Sydney in 1882 and the South Australian School of Mines in 1890. By 1900 technical colleges were educating engineers in New South Wales and Victoria. The authors also make extensive use of biographical material for the period before 1920.

In their earlier work, Rice and Lloyd developed a model for the engineering labour force which, in its simplest form, was concerned with annual aggregates and with the net gains each year from the additions minus depletions within the profession. For this latest report, however, they refined this model by segregating the three streams — university/college entry, pupils/apprentices, and immigration — and applying the net gains-over-depletions appropriate to each. This has allowed them, for example, to take account of the later average age of entry of immigrant engineers into the labour force in comparison with Australian university and college graduates. They have, however, applied post-1920 survival rate experience to the earlier period since none was available for the earlier period.

Some of the results of the analysis in this second chapter illustrate the kinds of information generated in this book. For example, from the 50 in 1850, the engineering labour force grew to just over 1,000 in 1900 and to just over 2,500 in 1920, this latter figure having been checked from the records of the Institution of Engineers and the three associations that remained outside it. In 1900, 60 per cent were Australians (25 per cent university/college and 35 per cent pupils/apprentices), and 40 per cent immigrants. By 1920 the Australian component had risen to 71 per cent (including a fall to 23 per cent for pupils/apprentices), and had fallen to 29 per cent for immigrants. From biographical information the authors were able to estimate the distribution of immigrants in 1920 between those with formal education (one-third) and the pupils/apprentices (two-thirds). As might be expected, the age distributions in 1900 and 1920 were different, with more younger men in 1900 and more mature ones in 1920. From biographical information, the authors were also able to estimate that, between 1900 and 1920, the percentages of civil engineers fell from 57 to 50 per cent of the total, mechanicals fell from 22 to 19 per cent, and electricals rose from 14 to 24 per cent, while mining remained constant at seven per cent. These figures, say the authors, reflect the maturing of the economy. On the other hand, in comparison with the United States and the United Kingdom — both countries at very different stages of development — Australia in 1900, and especially by 1920, had fewer engineers per million of population.

The chapter dealing with the engineering labour force from 1920 to 1990 leans heavily on information gathered by the Institution of Engineers, but also makes use of other sources, such as the Bureau of Labour Market Research and the Australian Bureau of Statistics. As the authors note, the labour force developed during this period under the influence of the Institution, with its examination qualifications and drive for upgrading engineering education. But in spite of the more readily available and better quality database for this period, the authors have still to make a number of important but well-balanced assumptions since some gaps still exist in the statistics. Immigration is one example, both with regard to numbers and to the qualifications which the immigrants brought with them — and especially when this mode of entry to the profession assumed added importance in certain years after 1945. The figures in ch. 3 have also been corrected to allow for foreign graduates of Australian institutions who returned home and did not join the labour force. Rice and Lloyd have also demonstrated their experience with, and understanding of, the different sources of recent data, building on the work they did in their earlier reports. They have also taken into account changes in the formal education system in Australia during this period as engineering moved more and more to being a degree-based profession. And as they did for the previous period, the authors applied validity checks to their estimates from material available for particular years.

By the beginning of 1990 engineers represented 1.14 per cent of the Australian labour force. Some 78 per cent of the 92,000 plus of them had qualified for inclusion through the universities and colleges of Australia, and 21.5 per cent were immigrents. The remainder (estimated at fewer than 500) had come the pupil/apprentice route. Private sector employment accounted for 60 per cent, and the public sector for 40 per cent.

The principal thrust of the fourth chapter is the *relatively* poor showing of recent engineering graduation numbers in Australia in the decade in question in comparison with the corresponding one for the natural and applied sciences and with engineering ones in the Pacific Rim and other countries. This is in spite of the fact that the actual numbers of graduates in engineering increased between 1977 and 1987. Although the authors do not correct the Australian figures for foreign nationals returning home after graduation (as they did for the previous chapter), the implication is that such a correction would not really help the Australian position. In 1987, for example, the relevant male age cohort qualifying in engineering in Australia was lower than the corresponding figures for most other industrialised countries. Rice and Lloyd comment, on the other hand, that the increases in graduates that took place in the mid-to-late-1980s included more women than before. And they show that the discipline in which the increase was largest was electrical engineering, with chemical and mechanical also benefitting, and civil bearing the brunt of the drop among the disciplines.

This chapter also includes a lot of interesting analysis of recently graduated engineers by function, and in an international context. Indeed, the authors conclude that Australia's engineering deficiency problem is associated, in part, with the relatively small number of engineers employed in research and development compared with the situation in some other countries and, in part, because of the relatively lower percentages of engineers employed in manufacturing and management. Clearly, this chapter may be considered as providing most of the groundwork for the fuller report on international comparisons promised later in the series.

The last chapter is the least satisfying of the five, attempting as it does to

analyse the engineering population in the late 1980s by state, based mainly on surveys conducted by three different organisations in 1982, 1986 and 1987-90. The main conclusion — that in relative terms the most advantaged state is Victoria — holds up well enough in the circumstances. Yet the question of the physical, resource, industrial and other *differences* between the States does not seem to have been dealt with adequately. Also, engineers tend to be migatory, so that a national aggregate figure for all engineers might mean more in policy terms if it is disaggregated by industry and industry location (and by government employment location) rather than by state. This does not, however, detract from the value of *knowing* where engineers are at a point in time. Nor does it alter the overall thesis that the country *as a whole* appears to be graduating fewer engineers than it should, or that engineering as a profession is sufficiently unattractive to too many potential entrants.

Indeed, this particular book provides not only the groundwork for international comparisons of the characteristics of the profession of engineering, it also serves as the starting point for more extensive analyses of the contributions which engineering has made to economic growth and development than have so far been done. Too much attention has been devoted in recent years to the role of R&D and science and not enough to engineers and engineering, and too much to the future without corresponding glances at the past and what was well, or not so well, done in the past in the management and application of engineering.

Australia has been well served by this book. Its authors have succeeded in what they set out to do. It should be especially useful — as well as interesting — to policy people, educators and historians. There are a lot of other countries that must now catch up to it and produce the kinds of research and time series computations that Rice and Lloyd have done through it.

NOTES AND REFERENCES

1. For example, see B.E. Lloyd, *The Education of Professional Engineers in Australia,* 3rd ed., APEA, Melbourne, 1968; M.R. Rice, *The Supply and Demand for Professional Engineers in Australia,* APEA, Melbourne, 1969; and B.E. Lloyd and M.R. Rice, *Labour Market Roles of Professional Engineers,* Institution of Engineers, Australia, Canberra, 1986.
2. The first book was Brian E. Lloyd, Michael R. Rice, William Roebuck and Eric Stokes, *New Pathways in Engineering Education,* Engineering Labour Force Series No. 1, EPM Consulting Group, in association with the Institution of Engineers, Australia and the APEA, 1989.

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