Foreword

I first met Min Xie in the 1980s at Linkoping University in Sweden. He was working with Professor Bo Bergman, the Professor in Quality at the University. As I recall, Min Xie was a very serious student of reliability theory at the time. He was very familiar with the book *Mathematical Theory of Reliability* by myself and Frank Proschan.

My first meeting with C. D. Lai was in 1999 at Massey University in New Zealand. I was impressed then by his serious interest in research.

The subject of this monograph is ageing and dependence in the context of reliability. Both of these ideas are important and controversial. Ageing is a phenomenon experienced by both machines and people. There has been a great deal of progress in understanding ageing relative to people by molecular biologists such as Giusseppe Attardi at the California Institute of Technology. Other researchers have even tried to apply ideas in mathematical reliability theory to biological ageing. Unfortunately, it seems that this is not a useful activity. This is because biological organisms are capable of self-repair and reproduction while machines at this point in time are not.

Probabilistic dependence has also been discussed at length by many mathematicians and philosophers. One of the best classical mathematical discussions can be found in *Statistical Independence in Probability Analysis and Number Theory* by Mark Kac (1959). However, this work is solely applied mathematics and leaves the subject somewhat mysterious at the philosophical level which is also the level at which applications need to be made.

From another point of view, de Finetti, in 1937, for the first time presented a rigorous and systematic treatment of the concept of exchangeability together with the fundamental result which became known as "de Finetti's representation theorem." [See Kotz and Johnson (1992)]. De Finetti's paper illuminates the conditions under which frequencies may be related to subjective probabilities (that is, probabilities based on judgment) and also formalizes this connection. It replaces the classical notion of observations assumed to be "independent and identically distributed with unknown distribution" by the concept of exchangeable observations. This helps to resolve the mystery behind the ideas of independence and dependence. De Finetti also helped in the understanding of conditional probability. Conditional dependence is closely tied to finite populations (i.e., all populations in this world) while unconditional independence is relative to conceptually infinite populations.

To illustrate, consider n binary random quantities $(x_1, x_2, , x_n)$ judged *a priori* to be exchangeable, i.e., distributed with the hypergeometric distribution with parameters (N, S) where $S = \sum_{i=1}^{N} x_i$ is unknown since in this case observations $(x_{n+1}, x_{n+2}, , x_N)$ are not available. Although N is known, S is unknown. We are interested in inference concerning S. Now $(x_1, x_2, ...x_n)$ are *a priori* dependent, conditional on S. However, if S has a prior distribution which is judged binomial with parameters N (the known population size) and

n specified, then $(x_1, x_2, , x_n)$ are *a priori* unconditionally independent, with joint probability

$$\prod_{i=1}^{n} \rho^{x_i} (1-\rho)^{1-x_i}$$

Since the binomial distribution with parameters (N, ρ) is only suitable for conceptually infinite populations, we begin to see the connection between independence and infinite populations. (In the binomial case, N would be the sample size, not the population size.) This is presented as an exercise on page 52 of Barlow (1998). It was pointed out to me by a colleague, Max Mendel. Of course once $(x_1, x_2, , x_n)$ are observed they are no longer random quantities. Any judgment concerning S would require knowledge of the problem at hand and this judgment is only partly a mathematical problem.

The present monograph deals with life distributions belonging to various classes of failure (hazard) rate functions and mean residual life functions. The so-called 'bathtub' distributions are featured prominently and a brief introduction of the Bayesian approach on ageing concepts is given. The text provides a lot of material on test procedures and bivariate life distributions, with various concepts and measures of dependence. The material concerning reliability of coherent systems with positively dependent components is very important as component lifetimes are generally dependent in practice.

The book should be considered as a very useful reference. Results of the last three decades are brought together without delving into unnecessary detail. The reader is referred to papers, which are listed in the bibliography. It covers most of results in the literature pertaining to ageing classes and bivariate life distributions; so it can be regarded as a compendium of ageing concepts. It is encyclopedic in scope, contains much information, and will be useful to researchers in reliability engineering and other disciplines.

Berkeley, September 2005 Richard E. Barlow

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