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Editorial

At long last the third edition of the New Zealand Statistician, in something like the form that I had envisaged, has appeared. That it has taken so long is largely my responsibility, although material for publication can hardly be said to have arrived spontaneously. However, relatively gentle prodding has produced a most satisfactory response. Because of illness in my family I was unable to find the time to undertake the prodding until recently.

My thanks go to the contributors. I feel that there is a future for the New Zealand Statistician provided it has the support of all members of the Association. It should, of course, not be necessary for the editor to solicit all material, and it is hoped that this issue will engender sufficient enthusiasm throughout the Association for the editor's task to be easier in future.

This issue contains, principally, a discussion on the training of statisticians at the technician level in New Zealand; and this topic is by no means exhausted. The provision of a medium for such discussion is, I feel, a primary function of this journal. It has been balanced by two short "technical" papers, one of fairly general interest, the other of a mathematical nature. There is a book review and the listing of New Zealand statisticians, in order to let members know something about each other and in what fields

they are working, is continued; and, unfortunately, there is an obituary notice.

At the Annual General Meeting in July you will be asked to decide the fate of the New Zealand Statistician. If you do not support it, I shall not complain, provided that you can offer in its place an alternative method for the dynamic development of the New Zealand Statistical Association.

W.G.Warren

STATISTICAL EDUCATION IN NEW ZEALAND

Under this general heading is first presented an article by Mr. H. Offenberger of Wellington Polytechnic. This article has been referred to a few members of the Association, in industry, in research and in education, for their comment. Those replies which have been received in time for publication are also presented, and it is hoped that others will follow. Indeed, any member of the Association who has thoughts on the matter is invited to advance them through these columns. (As editor I have taken the liberty to alter slightly the presentation of Mr. Offenberger's article without, I hope, in any way changing his content or meaning - W.G.W.)

THE EDUCATION OF TECHNICIANS IN THE FIELD OF APPLIED STATISTICS

General

The purpose of this article is to open a discussion by members of the N.Z. Statistical Association. Either there is no need for the special training of statistical assist-

ants, or a demand for statisticians at the technician level does exist. If we take the affirmative view, then the following is an assessment of the situation.

Employer's Requirements: If the technician is to work with a technologist, statistician or with management, these are the demands made on him:-

1. He must be able to understand and speak the technical language of statistics.
2. He must be able to understand the language of the field to which statistics is applied. In broad outline, he may be in the field of applied science or engineering, in the field of economics, of administration, or of commerce.
3. He must understand the elements of statistical theory, and the techniques of applied statistics.
4. He must understand the elements of numerical methods.
5. He must have computing skills which will include the use of desk calculators, and computer programming.
6. He must have an adequate mathematical background for (3), (4) and (5).
7. He must be able to recognise problems when they occur, and draw them to the attention of the statistician.

Employee's Requirements: The trained technician must be on the free labour market for positions in both Government and the private sector. He must, therefore, receive broad training in principles, deep enough, so that he is capable of "on the job" specialisation in a short time. He must be able to obtain a qualification recognized for salary and promotion purposes.

Possible Avenues toward a Qualification and their Relative Merits:

A. The Institute of Statisticians, London, examination leading to the qualification of "Registered Statistical Assistant".

The examinations can be sat in New Zealand by anyone who works in the field of statistics and has at least School Certificate, but the examination is held in June, and thus does not fit into the New Zealand academic year, nor does it cover all the aspects mentioned above.

B. The New Zealand Statistical Association which could
   (i) set examinations, or
   (ii) moderate examinations set by technical institutes to safeguard standards, or
   (iii) issue a qualification.

   In this way the disadvantages of (A) above could be remedied but no suitable mechanism to put any of (i), (ii) or (iii) into practice exists and accordingly something would have to be created.

C. Wellington Polytechnic courses in statistics which are presently available, but cannot serve more than local needs.

D. The Technicians Certification Authority, although no appropriate courses exist at present. The advantage here is that a system for setting up courses and the certification of technicians is available on a national scale. On the other hand, the Authority will set up a Certificate if, and only if, it can be shown that the number of technicians to be trained is large enough, and that the demand for training will be continuous.

Tuition:

The tuition of any of the courses considered above could be undertaken by the Technical Institutes, and by the technical departments of secondary schools provided the Education Department gives the necessary permission.

Under the assumption that the conditions for the setting up of a Technicians Certification Authority Certificate can

be satisfied, the following structure is put forward for consideration by members of the N.Z. Statistical Association. The course follows the accepted structure of a five-year N.Z. Certificate with the usual exemptions, subject for subject, for the first two years.

First two years:

English, Mathematics 1 and 11 and any other four subjects of the first two years of the Certificates in Science or Commerce.

Year three:

Mathematics 111 and any one of Biology 111, Physics 111, Chemistry 111, Geology 1, Principles of Economics, Laboratory Mathematics or Experimental Mathematics, Mechanics and Strenth of Materials.

Year four:

Mathematics 1V, Applied Statistics, Numerical Methods.

Year five:

Applied Statistics 11, Computer Programming.

The Certificate could be known as the N.Z. Certificate in Science (Statistics). A variation could be a subject Elements of Statistics presented at year three instead of Laboratory Mathematics or Experimental Mathematics; this could, perhaps, be a subject of the N.Z. Certificate in Commerce.

Intention: It is hoped that users, or potential users of statistical assistants, will come forward with criticism of this article and state their own views on any aspect of this subject: the need, the requirements and the avenues and content of training.

H. Offenberger
(Edited W.G.Warren)

RESPONSE

The first comment comes from Mr. T. Naylor. He sums his views up with the statement that ".... it will be difficult to get industry to accept any more than a "cook book" approach as an adjunct to existing activities. Such an approach however, could pave the way to the next generation being more receptive to the trained statistician". The full text of his comment follows as an article.

ONE VIEW OF INDUSTRIES' STATISTICAL REQUIREMENTS

In general, industry seems to have a fear of too well qualified people unless they are an insignificant minority. The exception to this may be the employment of qualified accountants.

From limited experience, both overseas in a few countries and from observing at close quarters many industries in New Zealand, the requirements for even a full time statistical technician seem to be very remote. The majority of statistics that are called for are of the purely "head counting" variety with a positive distaste for any discussion on variability, random sampling or other simple statistical approaches.

For these reasons it is considered more desirable for industry to have a short course, say one year of evening training, for people trained in an already acceptable industrial job of the more functional type, to obtain a working knowledge of statistical methods and understandings. A certificate of proficiency could be given to anyone attaining an acceptable standard during the year.

Such a course would appeal to investigating-type accountants, engineers, production control staff, work

study staff and computer programmers.

The course should teach at least the use of statistical methods for:

1. Forecasting.
2. Allowing for random variation, normally distributed and otherwise, including Tchebycheff. The application of such variability to design, significance tests, student's t, chi squared.
3. Statistical quality control illustrated with as many examples from industry as possible.
4. Linear regression including standard errors, both simple and multiple, up to the limit of manual operation, i.e. desk calculator.
5. Analysis of variance and statistical experiments - EVOP.
6. Precision of measurements making up experiments and the effect of modifying precision in different variables.
7. Monte Carlo methods illustrated by queueing.
8. Activity sampling, its strengths and weaknesses.
9. Linear programming using graphical, simplex, transport and assignment examples.
10. Essence of digital computer uses for the above techniques without any detailed programming study.

The above suggestions are not intended to discourage the starting of a full statistics course, but to provide something which could be acceptable to industry during the next 10-15 years, if not more.

The standard suggested would be as found in:

(a) Facts from Figures — Moroney

(b) A New Approach to Statistics — Wallace & Roberts

(c) Statistical Quality Control — Grant

(d) Regressional Analysis of Production Costs and Factory Operations — Philip Lyle (Oliver & Boyd)

(e) Introduction to Operations Research
Arnoff, Achoff & Churchman

(f) Linear Programming
Naylor & Byrne

(g) Handbook of Engineering Fundamentals (Section on Precision of Measurements)
Eshbach

T. Naylor.

Other Comments

The other comments follow something of a pattern and I have attempted to amalgamate them.

Concerning the demand for technician training in statistics we have ".... development will depend on such an unknown as how many people qualifying in a year will find suitable employment, it seems .... the outlook is promising. Many government departments (such as Health, Social Security, Labour etc.) are gradually beginning to use statistics to help their inferences and they would be helped if there were a certificate, such as that recommended, as a guarantee of a reasonable level of statistical thinking." Although the actual demand may be unknown there is little doubt in another commentator's mind that it exists in substance: "The 'Situations Vacant' columns of our newspapers offer ample evidence of the demand for trained personnel at the 'technician' level - and even if they did not this would be because we failed to get across, not because there was no real necessity for such people".

That there would be sufficient demand is questioned by only one commentator although he recognises a demand within his own area. He also echoes Mr. Naylor's remarks when he suggests that recruits for study in statistics at this level "could include graduates, e.g. chemists, chemical engineers,

etc., as well as non-graduates. They may, of course, wish to do the statistics courses without getting involved in other subjects for the N.Z. Certificate of Science, if this came to be the accepted course. They would also want to complete the courses in a short space of time, say six months per subject."

Concerning the four suggested avenues towards a qualification, the first, the Institute of Statisticians, London, has, on one hand, been dismissed with the remark "Don't see much point in working with London" and, on the other, been looked at quite seriously; "I agree that A (through the Institute of Statistician's examination) would lead to a different qualification, but the teaching would still have to be done here. The timing may be inconvenient but, as the course would be independent of others given, this should not be insurmountable. Nevertheless it is likely to be unpopular - from pure prejudice if nothing else - because "everyone knows" that exams should be held in November, no matter how inconvenient that may be; and so we reject A on the grounds of timing".

The response to proposal D, the Technician's Certification Authority, is fairly uniform. "The proposal with the greatest attraction seems to be D: "The Technician's Certification Authority is probably the most suitable authority for administering the course, qualifications, etc. The Education Department run the examinations for them at present and these seem quite satisfactory." "A course within the New Zealand Certificate of Science seems a good idea."

The role of the New Zealand Statistical Association also seems clear. A comment listed above refers to "a certificate .... as a guarantee of a reasonable level of

statistical thinking" and continues "This guarantee would be most meaningful initially if it were known that the professional body in the field, the N.Z. Statistical Association, was watching the quality of the examination as suggested in B." From a second commentator we have "The N.Z. Statistical Association could act as advisors to the syllabus, and moderator to the examinations. To do more than this needs greater administrative facilities than the Statistical Association has at present, or is likely to have in the forseeable future". Another commentator rightly points out that "abstract bodies don't do anything, people do", and continues "The Statistical Association does not have the clerical machinery to undertake the organisation of such an examination, but if the T.C.A. sets up such a Certificate, the people asked to set and/or moderate, and mark, the examination will be members of the Statistical Association - or should be! - so that B and D are equivalent."

This is indeed this commentator's thesis, that the four avenues, and particularly B, C and D, are but little different in practice. For example "If the Wellington Polytechnic courses (C) are extended to other centres some co-ordination is required - and by who else than the T.C.A.?" "Hence B, C and D all reduce to effectively the same thing; a new T.C.A. certificate, taught by the Technical Institutes, with relevant papers set by members of the Statistical Association (who may, but need not, be from the Institutes concerned)."

Finally one has to consider the syllabus in detail. Mr. Offenberger has so far outlined only a general scheme, and this is adequate for opening discussion. The commentators naturally have looked also to the next stage; "The Wellington Polytechnic Courses seem very adequate and I would like to see their syllabus made available for comment"; "The discussion

of the proposal would be assisted if the prescriptions for the relevant suggested courses, namely, Experimental Mathematics, and the courses in years four and five were available".

As regards general outline, it has been pointed out that "Laboratory Mathematics already includes some statistics and may need to be modified correspondingly if it is intended as an optional paper in the third year. But the omission of statistics from Laboratory Mathematics would be undesirable because we do not wish to push statistics out of the other Certificate courses because of the introduction of this new one. The alternative of Elements of Statistics and Presentation of Data - but a shorter title please! - with Laboratory Mathematics staying as is for the other Certificates, would seem to be preferable."

Just prior to going to press an additional comment was received. As it contains some fresh ideas I have not attempted to amalgamate it with the others but present it here more or less in tact.

"The New Zealand Statistical Association is rightly concerning itself about problems of training in the profession and the ideas suggested by Mr. Offenberger represent a great step forward.

Possible Qualifications:

"It seems highly desirable that the level of any qualification should be easily assessed by any employer, relative to qualifications in other fields. Suggestions A, B and C do not fulfil this, but the New Zealand Certificate in Science does. The Certificate is coming to be well recognised as more students complete it, and it carries salary recognition in the State Services. Its standing relative to a degree is clear and it provides a very suitable framework for the type of training desired.

Demand and Supply:

The likely obstacle to a successful scheme is lack of people, at two levels. The demand for specially trained statistical assistants is strongly related to the supply of professional statisticians with whom they could work. It would be wrong to al ow a situation to develop where holders of the certificate were employed on their own, virtually as professional statisticians. Laymen would undoubtedly give them problems which required treatment beyond the scope of their course training.

Perhaps the problem of finding enough suitable students for the course might be solved if a course were established so that recruiting could be slanted towards the certificate. At present most young people with the ability to take such a course want to try their hand at a full degree, or else they are unwilling to undertake any study after leaving school. Of the people employed as statistical assistants, whom I have come into contact with in recent years, at most 20% would have undertaken and completed a Certificate in Science, had it been available."

I wish to record my thanks to Miss J.G. Miller, F.A. Coulter, J.H. Darwin, H.S. Roberts and T.G. Robertson who generated the ideas which I have tried to collate above.

W.G. Warren

News of Members: Dr W.G. Warren, biometrician at the Forest Research Institute, Rotorua, has accepted a position with the Forest Products Laboratory, Vancouver, Canada. He expects to take up his new post towards the end of this year.

Conference - see P.24.

STATISTICS IN EDUCATION

Association members may be interested in the progress of the Association's efforts to have a meaningful programme included in the secondary school syllabus. The following letter was received from Mr. H.S.Roberts last November. Because of the unanticipated delay in publishing this issue of the New Zealand Statistician the information is hardly stop-press news, but still merits being put on record.

"Statistics is now included in the School Certificate Mathematics for the Pilot Scheme schools. Unfortunately, there is no satisfactory text-book for this. However, it might be possible to use the Bulletin which I am preparing at present, as a text for this purpose without much addition. The Pilot Scheme experiment will probably continue for two or three years more, when a decision will be made as to what mathematics shall be taught to the whole population of New Zealand schools.

"It seems almost certain that Statistics will be included in the new "Applied Mathematics" paper for the 1968 U.E. examination, taking up about half the paper. A course on statistics for teachers was run by the Wellington Mathematical Association in August last, with Professor Jowett as the lecturer and Mr. Bruce of Wellington Polytechnic and myself as tutors. The course lasted three days and the text used was "General Mathematics - An Introduction to Tertiary Courses" by J.B.Fitzpatrick, published by the Jacaranda Press, Melbourne for 45/-, There is no satisfactory text for this level, and it is the intention of Professor Jowett and myself to try and write one in the next year or so. The Dunedin teachers have had courses by Professor Jowett. In Auckland it is hoped to get similar courses for teachers next year, and Dr.Seber has offered to run such a course. Christchurch and Palmerston North

teachers are also considering running courses."

H.S.Roberts

BOOK REVIEW

Statistics and Experimental Design: in Engineering and the Physical Sciences, Volume 1. By N.L.Johnson and F.C.Leone. (Wiley, N.Y.1964, xiv + 523 pp.)

In the introduction to this book the authors state that it "was written primarily for workers in the physical and engineering sciences." While the examples would provide engineers with some solid ground from which to orient themselves, I feel that as far as this country is concerned they would find the sophistication of the text a little beyond them. There are also special features like the chapter on control charts which would tend to make it useful in industry, but while taking this into account I propose to evaluate it mainly as another in the seemingly endless procession of statistical texts coming from the publishers these days. As such it is no doubt quite adequate, and indeed it has some very good features.

The first five chapters deal with the usual introductory statistical material of empirical distributions, descriptive measures, probability theory, discrete and continuous distributions in much the usual way. I wonder in passing why it was thought necessary to define factorial moments when no use is made of them. I feel too that the t and F distributions should not be introduced by definition but derived in the appropriate place as sampling distributions. Chapter 6 on order statistics is good, except for two notable omissions considering the readership aimed at. There is no mention of extreme values, something a design engineer should not be able to do without, and the application of order statistics to life testing is ignored.

There is a very good discussion of hypothesis testing and estimation in chapter 7, with a special chapter (11) giving a formal outline of the way in which prior information may be utilized,an inclusion still unfortunately not standard in texts at this level. The dangers of blind acceptance and use of Bayes' Theorem are emphasized, but its value in certain circumstances and subject to certain limitations pointed out. After dealing with the standard tests of significance in chapter 8, the book goes on to present a good selection of non-parametric tests. Issue could perhaps be taken at the inclusion of confidence intervals for percentiles, when something like the corner test for association is excluded.

Quite the best thing about chapter 10 (on control charts) is the definitive section on cusum charts, which although not new have not found their way into many industrial statistics books. Completing the volume is a chapter on regression and correlation which, long though it is, does not go beyond the most elementary cases, and gives no guidance to the person searching for the solution to the slightly off-beat problem, or indeed to the practical handling of ordinary situations, for example multiple regression. It should be noted that the test of $H_o: \alpha = \alpha_o$ on page 394 is only possible if $H_o: \beta = \beta_o$ is true.

On balance, then, how do we assess this book? Until I see Volume 2 I cannot attempt a complete comparison with outstanding books like Bennett and Franklin or Anderson and Bancroft, which do the same thing for respectively the chemical and agricultural industries. On the partial evidence before me it loses out. It takes two volumes to do what they do in one, and it would have been the better for some severe pruning which would have allowed the inclusion of more material. However, it does contain useful

supplementary material for the statistician connected with industry, and he could possibly be interested in it as an addition to his library, but certainly not as his sole work of reference.

H.R.Thompson.

A LISTING OF NEW ZEALAND STATISTICIANS

(Continued)

JACOBY, E.G. LL.D. (Keil, Germany, 1929)
Dr. Jacoby is presently Senior Research Officer with the Department of Education, and has been in the Department since 1948. He has experience in demographic and educational statistics and research, and held a Rockefeller Foundation Fellowship in Social Science in 1956/57. Not surprisingly, he lists his interests as demography, sociology and education.

McKINNEY, Jack Bolton, M.A., Admin. Prof.
Mr McKinney is Editor of Publications, Department of Statistics, Wellington, and has been Editor in the Department since 1957. His main publication is the Official Yearbook, but he is concerned with many other statistical publications. He was previously assistant to the Medical Editor, Sir Duncan Stout, and prepared statistical material for publication in three medical history volumes of the Second World War. His interests lie in the demographic, social and economic applications of statistics.

OBITUARY

Mr A.C.Glenday

One of New Zealand's ablest biometricians, Mr A.C.(Arch) Glenday, of the Applied Mathematics Division, D.S.I.R., died suddenly at his home in Palmerston North on 23rd March 1967. He was 51.

Mr Glenday was attached to the Palmerston North Divisions of the D.S.I.R. as a statistician. In this capacity, he contributed substantially to the Department's agricultural researches there during the past 16 years.

In addition to his work for the Grasslands, Plant Chemistry and Plant Physiology Divisions, Mr Glenday also gave services to a variety of other institutions. He lectured on statistics at Massey University, and acted as statistical consultant to the Dairy Research Institute, the Palmerston North Hospital Board and the Palmerston North City Council.

Born in 1915, Mr Glenday studied at the Timaru Boys' High School and at Canterbury University, from which he graduated B.A. in 1935 and M.A. in 1936.

In 1938, he went to England, where he joined the Royal Air Force. During the war he was posted to Canada for some years as an instructor. During a period in hospital following his transfer back to England, he used his time in study, and later went on to graduate B.Sc.Hons. from London University.

Invalided out of the R.A.F. in 1949, he returned to New Zealand, took a post-graduate course in mathematics at Canterbury University, and joined the staff of the then Applied Mathematics Laboratory at Wellington.

In 1950, he was transferred to Palmerston North as

statistician to the Grasslands Division, then the only D.S.I.R. Division in the city. He played a vital role in the Department's expanding research programme there, both in assessing the significance of research findings and in the planning of research projects on sound lines. He took the trouble to acquire a thorough understanding of the problems and requirements of the research divisions and the primary industries they serve, taking the view that this was the greatest contribution he could make to research.

Most of his published work is in the form of joint papers with agriculturalists and biochemists, and this truly reflects his deep involvement in their projects, but some can stand in its own right. Of the mathematical work he did, perhaps the most important was that on the mathematical separation of plant and weather effects in field growth studies, published in 1955 in the Australian Journal of Agricultural Research, and followed by a mathematical analysis of growth curves replicated in time. More recently, he worked on the interaction between weather, plant competition and stage of growth, and the development of intervarietal indices in grass species.

Arch's one great hobby was fishing, which he pursued with an enthusiasm similar to that he showed in his work.

He is survived by his wife Alice, whom he met and married during his wartime service in Canada, one daughter and one son.

(Based on an obituary notice in the Manawatu Evening Standard of 25/3/67 written by M.J.Roche, Information Officer at Grasslands Division.)

Members of the Association, I am sure, will join with me in expressing sorrow at the untimely death of a respected member and valued friend. - W.G.W.

FORECASTING MANUFACTURING TRENDS

by W.A.Poole
N.Z. Insitute of Economic Research (Inc.)

The Institute has now completed 24 quarterly surveys of business opinion, covering the period June 1961 to March 1967. These surveys are conducted by means of postal questionnaires addressed to the heads of business houses - manufacturers, builders, wholesale and retail traders, and, latterly, service industries. The manufacturers' questionnaires cover most of the main business variables, e.g. numbers employed, new orders, output, stocks, etc., in an unquantified way. Each quarter the respondent is asked to report, with reference to his own firm, on the direction of movement of the variable over the past three months by indicating whether the movement was "up", or "same", or "down" for the period, and he is also asked to forecast the movement for the coming three months, again by indicating "up", or "same", or "down"[1]. The objective of the surveys is to ascertain the direction and strength of current business trends, very rapidly - usually well in advance of the conventional quantitative indicators.

The present exercise is concerned with the ability of manufacturers to forecast their own trends at the downturn of economic activity and through the downswing phase of cyclical activity. It is true to state that, in general, during the currency of these surveys the manufacturers have experienced continuing business expansion, except for the first few surveys (conducted in

[1] In reporting the past three months and in forecasting the next three months, the respondent is asked to exclude seasonal variations.

1961) and in the latest survey (No. 24, 31 March 1967). To test the accuracy of the respondents' forecasts of their own trends the individual forecasts and outcomes of all the respondents that answered all three surveys in 1961 were scrutinised over those same three surveys.

There were just over fifty manufacturing respondents, and nine questions were common to all three surveys. As respondents did not always answer all nine questions per survey the total numbers of forecasts checked per question are usually less than fifty. Considering successive surveys, made at times t_1 and t_2, the forecasts for the "next three months" made at t_1 have been checked with the reported outcomes of the "past three months" registered at t_2, and classified as correct or incorrect respectively. There are two series (June and September, and September and December) both of nine questions each of which covers up to fifty forecasts.

If the respondents forecast at random, the probability of any given forecast being correct, as indicated by the subsequently registered outcome, is $P(C)=1/3$. Theoretical frequencies of correct and incorrect were calculated for every question of the two series on the hypothesis $P(C)=1/3$, and tested for significance against the actual frequencies by means of a simple chi-square test with one degree of freedom. In general this hypothesis is not supported by the chi-square tests. Significant values of chi-square were obtained for seven of the nine questions in the first series and for all nine questions in the second series. Probabilities of correct forecasts were generally greater than the hypothesis indicated.

Two alternative hypotheses based on arbitrary assumptions were then tested, viz. (a) $P(C)=\frac{1}{2}$; and (b) $P(C)=2/3$. In general hypothesis (a) corresponds well with the observed data, there being only one question in each series for which significant

values of chi-square were obtained. Hypothesis (b) does not correspond quite so well with the observed data, there being five questions in the first series and two in the second series for which significant values of chi-square were obtained.

Finally the hypothesis that the two series were homogenous with respect to the probabilities of correct forecasts of the corresponding questions was tested by means of nine 2x2 contingency tables. No significant values of chi-square were obtained.

The results of these tests do not indicate that the manufacturers were especially good at forecasting their own trends in 1961. The probability of any given forecast being correct was only slightly greater than 0.5. It would be valid to accept the probabilities of correct forecasts based on the first series as a guide to the accuracy of forecasts in the second series. This argues that the manufacturers were not significantly better at forecasting at their second attempt than at their first, and possibly that they were no better at forecasting a more clearly established trend than they were at forecasting the actual downturn. Further data on forecasting declining business trends will have to be collected to test these inferences more rigorously.

Errata: Some errors in Volume 1, No.2 have been noticed. Mr B.H. Easton's paper "Spectral Analysis and some Economic Applications" was described as not being excessively vigorous - rigorous was intended. In Mr R.D. Clarke's paper, "Inventory Control", the impossible accidentally became possible. On page 11 there is another classical mistake (see page 16).

Conference & Annual General Meeting see P.24

Appendix

Manufacturers' Forecasts in 1961

Question	First Series June-September					Second Series September-December				
	Forecast		significance on hypothesis P(C)=			Forecast		significance on hypothesis P(C)=		
	C	NC	1/3	½	2/3	C	NC	1/3	½	2/3
Numbers Employed	35	14	1%	1%	-	29	22	1%	-	-
Overtime Worked	26	23	1%	-	5%	26	23	1%	-	5%
Labour Turnover	29	20	1%	-	-	33	18	1%	5%	-
All New Orders Received	17	21	-	-	-	25	15	1%	-	-
Length of Order Books	13	20	-	-	1%	20	16	1%	-	-
Output	30	18	1%	-	-	23	26	5%	-	1%
Deliveries in N.Z.	27	16	1%	-	-	27	20	1%	-	-
Stocks of N.Z. Raw Materials	22	21	5%	-	5%	25	17	1%	-	-
Stocks of Finished Goods	22	24	5%	-	1%	25	18	1%	-	-

C = correct; NC = incorrect; - = not significant.

ASYMPTOTIC VARIANCES in MULTINOMIAL DISTRIBUTIONS

by G.A.F. Seber,
Auckland University

Let $x_1, x_2, \ldots, x_s$ have a multinomial distribution

$$f(x_1, x_2, \ldots, x_n) = n! \prod_{i=1}^{s} (p_i^{x_i}/x_i!) \qquad (\textstyle\sum_i p_i = 1)$$

then
$E[x_i] = np_i$ ($=X_i$ say), $\mathrm{Var}[x_i] = np_iq_i$ and $\mathrm{Cov}[x_i, x_j] = -np_ip_j$ $(i \neq j)$

Suppose we wish to find the variance of $t = (x_1x_2\ldots x_r)/(x_{r+1}\ldots x_s)$ an estimate of $T = (X_1X_2\ldots X_r)/(X_{r+1}\ldots X_s)$,

then by taking the first term of a Taylor expansion of t, considered as a function of $x_1, x_2, \ldots, x_s$ we have approximately

$$t - T = \sum_{i=1}^{s} (x_i - X_i)\left[dy/dx_i\right]_{\{x_i = X_i\}}$$

$$\text{i.e.} \quad \frac{t - T}{T} = \sum_{i=1}^{r} \frac{(x_i - X_i)}{X_i} - \sum_{i=r+1}^{s} \frac{(x_i - X_i)}{X_i}$$

As a first approximation we have $E[t - T] = 0$ and by squaring both sides and taking expected values we have approximately

$$\mathrm{Var}[t] = E[(t - T)^2]$$
$$= T^2\Big(\sum_{i=1}^{s} \frac{\mathrm{Var}(x_i)}{X_i^2} + \frac{2\,\mathrm{Cov}(x_1, x_2)}{X_1X_2} + \ldots. - \frac{2\,\mathrm{Cov}(x_1, x_{r+1})}{X_1X_{r+1}} - \ldots.\Big) \qquad [1]$$

Now
$$\frac{\mathrm{Var}(x_i)}{X_i^2} = \frac{np_i(1 - p_i)}{n^2p_i^2} = \frac{1}{X_i} - \frac{1}{n}$$

and
$$\frac{\mathrm{Cov}(x_i, x_j)}{X_iX_j} = -\frac{np_ip_j}{n^2p_ip_j} = -\frac{1}{n}$$

Therfore
$$\mathrm{Var}[t] = T^2\Big[\sum_i X_i^{-1} - \frac{s}{n} - \frac{2}{n}\Big\{\binom{r}{2} + \binom{s-r}{2} - r(s-r)\Big\}\Big]$$
$$= \frac{T^2}{n}\Big[\sum_{i=1}^{s} p_i^{-1} - (s - 2r)^2\Big]$$

We note that the second term vanishes when $s = 2r$.

Finally, we shall generalise the above formula to the case when each x_i is replaced by a linear combination of the x_i's; suppose

$$t = (y_1\ y_2 \ldots y_r)/(y_{r+1} \ldots y_s)$$

where $y_1 = \sum_{i=1}^{n} a_i x_i$; $y_2 = \sum_{i=1}^{n} b_i x_i$; etc.

Then if $Y_i = E[y_i]$. equation [1] is still true with x_i, X_i replaced by y_i, Y_i respectively. Also

$$\mathrm{Var}[y_1] = \sum\sum a_i a_j \mathrm{Cov}(x_i, x_j) = \sum a_i X_i - (\sum a_i X_i)^2/n = Y_1 - Y_1^2/n$$

and $\mathrm{Cov}\ y_1, y_2 = \sum\sum a_i b_j \mathrm{Cov}(x_i, x_j) = \sum_i a_i b_i X_i - Y_1 Y_2/n.$

Hence

$$\mathrm{Var}[t] = \frac{T^2}{n}\left[\sum_{i=1}^{s} Y_i^{-1} - (s - 2r)^2 + 2n\sum_{i=1}^{n} a_i b_i X_i / Y_1 Y_2 + \ldots.\right] .$$

Applications of the above formula are found in problems dealing with the estimation of animal population sizes using tagging, etc. (c.f. "Estimating population parameters from catches large relative to the population" by E.D. Le Cren & G.A.F. Seber - to be submitted to the Journal of Animal Ecology).

NOTICE

The Annual Conference will be held in the Shell Theatrette, Shell House, the Terrace, Wellington, on Tuesday, Wednesday & Thursday, 4th, 5th & 6th July, 1967 (in conjunction with the Operational Research Society of New Zealand).

Annual General Meeting

The Annual General Meeting of the New Zealand Statistical Association (Inc.) will be held in the Shell Theatrette at 11.30a.m. on Wednesday 5th July, 1967. The Agenda is :

1. Apologies
2. Minutes of A.G.M. 1966.
3. Matters arising
4. President's Report
5. Financial Report
6. Election of Officers
7. N.Z. Statistician
8. Courses in Statistics
9. General

(signed) G.Arnold,
Hon. Secretary.