OBITUARY: *Edward James Hannan*

Ted Hannan died in Canberra after a sudden heart attack on the evening of 7 January 1994. He had been his usual ebullient self during the day, when he had gone to work among his colleagues in the Department of Statistics at the Australian National University (ANU). On returning home, he told his wife Irene that he felt tired, and retired early. He called out to her at about 9.15 p.m., during his heart attack, and was promptly driven by ambulance to the Woden Valley Hospital. Despite the care he received, he died before midnight. His death has deprived Australia of one of its most distinguished statisticians, and the world of an eminent time series analyst. This tribute, which can hardly do justice to his life and work, is presented as a brief record of the achievements of a most unusual, talented and well-loved colleague and friend.

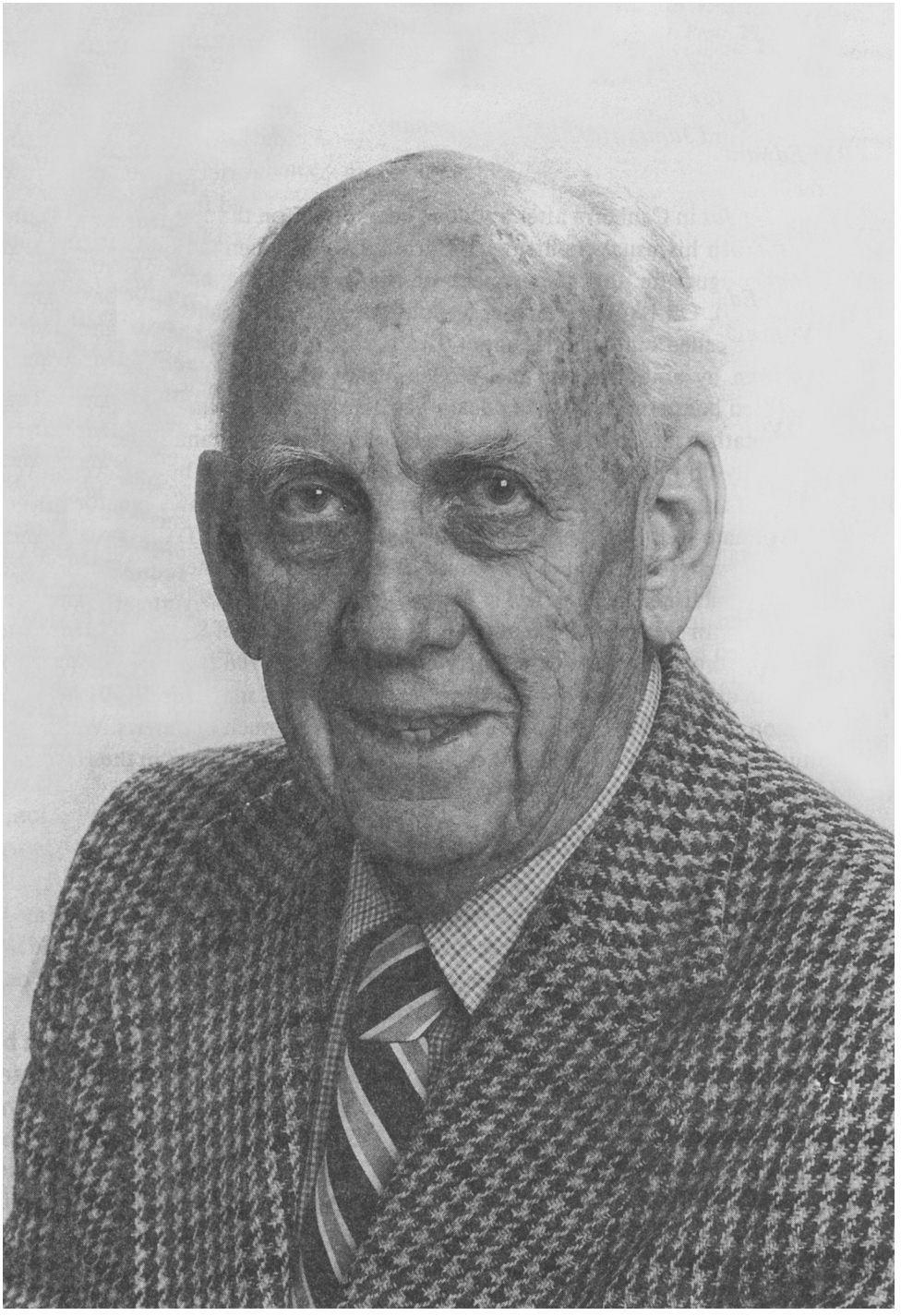
We are fortunate to have access to Adrian Pagan's interview of Ted for the journal *Econometric Theory* (1985), and to a personal article entitled 'Remembrance of things past' which Ted published in *The Craft of Probabilistic Modelling* (1986). These, together with the citations for the Lyle Medal of the Australian Academy of Science in 1979, and the Pitman Medal of the Statistical Society of Australia in 1986 (see Tweedie (1991)) provide us with useful accounts of his life, his research and his many other interests. We have drawn on these and on personal memories of Ted for much of our information; a fuller obituary, including a complete list of his publications, will appear in the *Historical Records of Australian Science* in 1995.*

1. Early life

Ted Hannan was born in Melbourne, Australia on 29 January 1921. His father James Thomas Hannan was a freelance commercial artist of Irish Catholic parentage, and his mother Margaret Josephine McEwan was of Anglo-Irish Catholic descent. He had one sibling, his twin sister Josie, a talented artist living in Melbourne.

Ted attended primary school at St. Fintan's College, St. Kilda, an institution run by nuns of the Presentation Order, and went on to Xavier College, Kew, for his secondary education. This was a good Jesuit school, where he excelled in his studies. He left the College at 15, after taking his Leaving Certificate. His father, who had lived through the Great Depression, advised him to take up a safe job, and he went to work as a clerk in the Savings Bank section of the Commonwealth Bank of Australia (CBA). He continued in this post until 1941 when he enlisted in the Royal Australian Army Corps of the 2nd AIF. He saw active service as a lieutenant in the infantry in northern New Guinea

* A shorter version of this account has appeared in the *Australian Journal of Statistics* **36** (1994) 1–8, with major differences in Section 5; in that journal Ted's influence on Australian statistics is stressed, while in this journal we concentrate on his contributions to the Applied Probability Trust.



Edward James Hannan
29 January 1921– 7 January 1994

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against the Japanese. He spoke very rarely of his war experiences, and then tried to make light of the dangers he had faced in the New Guinea campaign. He had in fact once been wounded in an ambush and evacuated from the front.

At the end of World War II in the Far East, he was repatriated to Melbourne in 1946, and decided to take advantage of the Commonwealth Reconstruction and Training Scheme offered to ex-servicemen, to enrol for a degree at the University of Melbourne. Almost by accident, he joined the Faculty of Economics and Commerce in 1946, because it had a minimum of prerequisites. In the course of completing his B. Com. degree, he took thirteen subjects, ten in economics (including the Keynesian theory of money and banking, and public finance), two in mathematics (pure mathematics I and II, the latter taught by Hans Schwerdtfeger) and one in statistics (taught by Maurice Belz). The last three subjects sparked off his enduring interest in mathematical and statistical theory. On completing his degree in December 1948, he decided not to continue with the final Honours year: he wanted to get married to Irene Trott, and would not have been able to afford it if he had remained a student. They were married in Melbourne on 1 March 1949.

Ted was offered a job at the CBA in Sydney, in what was to become the Reserve Bank of Australia after 1959. He and Irene moved there directly after their marriage in 1949. He worked mainly as a statistician, calculating average interest rates, reconstructing an index of import prices, and building a small model of the Australian economy by Limited Information Maximum Likelihood (LIML) methods to find a consumption function. Partly in connection with his work, but mostly out of personal interest, Ted read a great deal of modern mathematics and statistics, as some of the textbooks in his library attest.

2. Academic career

In 1953, H.C. Coombs, then Governor of the CBA and one of the founders of the Australian National University (ANU), chose Ted to spend a year studying with Professor Trevor Swan at the ANU Department of Economics. There, Ted's exceptional talent in mathematics was recognised by Professor Pat Moran, who persuaded Coombs to give Ted two years' leave without pay, and arranged a Research Fellowship to allow him to work towards a PhD in his Department of Statistics. Ted never left the ANU; he was awarded his PhD in 1956 for a thesis on '*The Theory and Application of Stochastic Processes*', and remained as a Research Fellow in Moran's Department until 1958.

In 1959, he was appointed to a Professorship in Statistics at the Canberra University College, then a college of the University of Melbourne later to become the ANU School of General Studies (SGS), the undergraduate section of the ANU now known as The Faculties. He was head of its Department of Statistics until 1970, when he decided that he could make a more valuable contribution by concentrating on his research. He then became the second professor in Moran's Department at the ANU Institute of Advanced Studies (IAS), the postgraduate section of the university. Freed of his teaching duties at the SGS, Ted made rapid progress in his research, and guided a large number of students working towards their PhDs. When Moran retired in 1982, Ted succeeded him as Head of the IAS Department of Statistics until the appointment of Chris Heyde in 1985.

In 1986, on Ted's retirement, the ANU appointed him as Emeritus Professor; he was offered a room and facilities in his old department at the SGS, where he continued to work until the very day of his death. He would usually be at his desk by 8 a.m. and would spend his time reading, writing references, reviewing papers for the many journals with which he was associated, and carrying out research. He often collaborated with past students who had returned to visit him at the ANU. He would leave to catch a bus home shortly before 5 p.m.; occasionally he would ask Irene or me to drive him home.

During 1993, Laimonis Kavalieris of the University of Otago joined him at the ANU in some research on ARMA models; he also corresponded regularly with David Huang and Barry Quinn on the book he was writing with them. His flow of ideas, many of them pioneering developments in time series analysis, continued unabated over a period of 40 years (1953–1993); he wrote over 130 papers and four very influential books (see Hannan (1960), (1965), (1970), (1988), with Deistler).

3. Scientific contributions

Ted's first paper, published in 1955, was concerned with singularities in Sydney rainfall. He retained his interest in hydrological and other climatic factors, as well as in geophysical data, throughout his career. He returned to the topic of seasonal variation in 1960, rainfall singularities in 1962, hydrological time series and seasonal patterns in 1964, the analysis of geophysical data in 1966, the effect of weather on sea level in 1968, rainmaking in 1973, and surface and plane waves in 1975 and 1978. He was a very capable data analyst, with a flair for the interpretation of large tables of numbers, but clearly preferred theoretical research.

His major contributions were to be in the field of time series analysis, of which he became one of the recognised authorities. Pat Moran had initially asked him to examine problems of serial correlation; this formed the topic of his second paper in 1955, and led to his third paper on an exact test for correlation between time series. He continued with investigations on tests based on multiple correlations, serial correlation in vector processes, serial correlation in regression, the estimation of spectral density and the asymptotic powers of goodness of fit tests in time series until 1960, when his famous monograph *Time Series Analysis* first appeared. It was destined to become a classic, later translated into Russian and Japanese.

During the 1960s, Ted pursued his research in time series modelling, possibly with a greater emphasis on econometric applications. He wrote several papers in this area, some individually, others jointly with Deane Terrell, his PhD student who was appointed Vice-Chancellor of the ANU in January 1994. Spectral inference formed the subject of other papers, some written with another student Peter Thomson, while he collaborated with Des Nicholls on estimation in ARMA and other models. In 1965, he published a second book on *Group Representations and Applied Probability*, a mathematical topic in which he drew together group theory and its applications in probability theory.

The book which many consider to be his masterpiece, *Multiple Time Series*, was published in 1970. This is a profound work, whose density sometimes masks the depth of his understanding of time series. Ted himself felt dissatisfied with it: he thought he

had devoted too little space to the Kalman filter, and to establishing the representation of a system in state-space form. He sometimes spoke of revising it, but unfortunately never got round to it. The 1970s were a period of broadening research into lagged regression with Peter Robinson, limit theorems in discrete time series where the prediction errors are martingale differences with Chris Heyde, rainmaking experiments with Pat Moran, multivariate time series, vector linear time series with Bill Dunsmuir and Manfred Deistler, ARMAX models with Katsuto Tanaka, the asymptotics of serial covariances, multivariate ARMA theory, the order of an autoregression with Barry Quinn, and transient signals with Murray Cameron.

A further flowering of his research activities took place in the 1980s, with investigations into the properties of ARMA systems with Manfred Deistler, multivariate ARMA models, Akaike's criterion, autoregression and ARMA estimation with Hong-Zhi An and Zhao-Guo Chen, ARMA processes, autoregressions and multivariate linear time series with Laimonis Kavalieris, a law of the iterated logarithm with Margaret Mackisack, time series and stochastic models, canonical correlation with Don Poskitt, ARMA estimation with Andrew McDougall, rates of convergence with Christian Hesse, spectral windows with Jorma Rissanen and non-parametric estimation with Peter Hall. In 1988, his last book on *The Statistical Theory of Linear Systems* with Manfred Deistler appeared.

One might have expected that as he approached his 70th year, Ted would begin to slow down. But he was still brimming over with ideas, though he would often remark that as he grew older, he found the help of younger researchers a stimulus in exploring their details. He collaborated with Bo Wahlberg on convergence rates for inverse Toeplitz matrices, with David Huang on line frequency estimation, and wrote a paper on frequency estimation for the Whittle Festschrift, to appear in mid-1994. He was in the process of writing a book with David Huang and Barry Quinn during 1993; this work is to be completed by his two younger colleagues. A detailed analysis of Ted's work by Peter Robinson (1994) will shortly be published.

Of his work, Ted probably thought most highly of his paper on spectral regression arising from his collaboration with Bruce Hamon (1963) of CSIRO on waves, his monograph on *Group Representations and Applied Probability* (1965) where he displayed his deep grasp of mathematical theory, his papers on seasonal adjustment, his book on *Multiple Time Series* (1970) and his last book with Manfred Deistler on *The Statistical Theory of Linear Systems*. But his views about his work were difficult to pin down, with his modesty usually getting the better of him. He tended to dismiss his renown as being 'a bit generous'. Nevertheless, the corpus of his research indicates a deep approach to problems, backed by a rigorous mathematical technique. He emerges as perhaps the best-known international time series analyst of the past 30 years.

4. Recognition

After the publication of his *Time Series Analysis* in 1960, Ted rapidly received international recognition for his research achievements. He was frequently invited to lecture at overseas universities, and address conferences in Europe, Britain, the USA, Japan and China. He held visiting appointments at the University of North Carolina,

Chapel Hill, NC; The Johns Hopkins University, Baltimore, MD; Brown University, Providence, RI; Yale University (The Cowles Foundation), New Haven, CT; Princeton University, Princeton, NJ; MIT, Cambridge, MA; and IBM (The Almaden Research Center), San Jose, CA.

In 1970, Ted was elected to Fellowship of the Australian Academy of Science, and in 1980 to Fellowship of the Academy of Social Sciences in Australia for his contributions to econometrics. He was also a Fellow of the Econometric Society (1967), an Honorary Fellow of the Royal Statistical Society and an elected Member of the International Statistical Institute (1967). He was asked to serve on the editorial boards of numerous journals, among them *Advances in Applied Probability* and the *Journal of Applied Probability*, the *Annals of Statistics*, *Econometrica*, the *International Economic Review*, the *Journal of Forecasting*, the *Journal of Multivariate Analysis* and the *Journal of Time Series Analysis*. He was in constant demand as a referee by many more.

In 1979, the Australian Academy of Science awarded Ted its Lyle Medal; his citation reads:

> Professor Hannan has made many fundamental contributions to the theory of statistical inference, particularly in connection with stationary random processes. . . His researches are based on a deep mastery of functional analysis and group theory.

Seven years later, the Statistical Society of Australia presented him with the Pitman Medal, its highest research award, for gaining Australia 'a world-wide reputation as a centre of excellence for time series analysis' (see Tweedie (1991)). In 1986, on the occasion of his 65th birthday, he was also honoured with a Festschrift entitled *Essays in Time Series and Allied Processes*, edited by J. Gani and M.B. Priestley and published as a Special Volume 23A (1986) of the *Journal of Applied Probability*.

Ted clearly enjoyed the recognition he received, yet he remained singularly unaffected by it. He was not by nature inclined to reverence; although he had been brought up as a Catholic, he was not at all devout. He would often comment, however, on the profound mystery of life: he thought there was 'something behind it', but would seldom go further than this general expression of faith. He could not abide pretentiousness, and used to poke fun both at pompous colleagues and at himself; in one of his articles, he noted 'how unbearable we can become as we grow old, stressing the obvious, repeating the same advice and telling the same stories!' Eminent though he became, Ted never lost sight of the respect owed to fundamental human values; he could never take the importance of himself or others too seriously.

5. The Applied Probability Trust

Ted Hannan had an enormous influence on Australian statistics: he founded one of the major departments of statistics in the country at the SGS, ANU, trained a dozen and a half postgraduate students, and brought Australia to the forefront of research in time

series analysis. But he also exerted considerable influence on international statistics, partly by his involvement in international journals, and partly through his participation in the creation of the Applied Probability Trust (APT).

During 1963, Ted joined with Joe Gani and Norma MacArthur to found the Applied Probability Trust, a foundation designed to foster research in mathematics, and more specifically probability theory. The APT's immediate aim was to launch the *Journal of Applied Probability* (JAP), a periodical dedicated to publishing papers in applications of probability theory to the biological, physical, social and technological sciences. At that time, no such journal existed, and papers in applied probability often failed to find acceptance in either mathematical or statistical journals. The three Australian Trustees raised £2250, half the funds then required to print JAP for one year; with the help of David Kendall, they obtained the other half from the London Mathematical Society who nominated a fourth Trustee, Sir Edward Collingwood. Thus, in 1964 JAP was launched; Ted was one of its first editors, and remained on the editorial board till his death.

In 1969, the APT decided to add *Advances in Applied Probability* (AAP) to JAP; once again Ted became one of its editors. AAP was originally conceived as a medium for the publication of review papers, but was later reserved for longer papers in applied probability and for Letters to the Editor. The APT also started *Mathematical Spectrum*, a magazine for students, in the academic year 1968–69, and took over *The Mathematical Scientist*, a journal for general mathematicians started by CSIRO, in 1976. Throughout the APT's years of development, Ted was intimately involved in its policies and direction; although he did not care for administrative duties, he took his role as Trustee very seriously, and would often cut through the complexities of a problem to offer a useful solution.

Ted's main concern was always the quality of the papers appearing in the JAP and AAP; he saw to it that the papers in time series maintained a standard compatible with his own exacting criteria. As Trustees, we would have regular discussions on the new directions taken over the years by the subject of applied probability, and on its sudden flowering in the biological, environmental, electrical engineering, hydrological and operations research journals. We noted with pleasure the progress of the field over the past three decades, as gauged by the number of periodicals now serving applied probabilists, among them the *Annals of Applied Probability*, *Operations Research* and *Mathematics of Operations Research*, *Queueing Systems: Theory and Applications*, *Stochastics*, *Stochastic Models*, *Stochastic Processes and their Applications*, and *Transactions of IEEE* as well as the various time series journals mentioned earlier in Section 4, on whose editorial boards Ted served.

Ted contributed to the growth of applied probability, partly through his influence as a Trustee of the APT, and partly through his lively interest in the applications of probability to the modelling and analysis of natural phenomena. His contributions to the field, and particularly to time series analysis, form an integral part of the tradition of applied probability.

6. The human dimension

No account of Ted Hannan's life would be complete without mention of his human interests. He was a devoted family man: he and Irene were married for 45 years, and raised four children, Christine, Jenny, Patrick and David, of whom he was immensely proud. Ted and Irene formed an inseparable pair whose fondness for, and understanding of each other seemed to require few words or explanations. Ted would often tell me how much he relied on Irene's judgment of people; he delighted in her company and would sometimes take the afternoon off to see a film with her. He occasionally felt that he might have neglected his family in an over-emphasis on his work, but nothing was farther from the truth. His feelings of inadequacy were due to the fact that his standards of caring were so high: he was deeply loved by his entire family.

He was much concerned with the health of his twin sister Josie, whom an early attack of polio had left partially crippled. He always spoke of her as 'an indomitable woman' who had made her way in the world, first as an artist in the Victorian Public Service, and later as a freelance. He cared greatly for his sister-in-law Marion and her husband Dick, who were regular visitors to Canberra and with whom he and Irene would spend occasional holidays. He was particularly fond of his six grandchildren whose exploits he would retail with relish, and with whom he was always very indulgent.

Ted was a good humoured and totally unpretentious person, despite his immense intelligence and sharp critical sense. He could laugh at himself, as when quoting from his favourite poet W. B. Yeats' lines in 'Youth and Age':

> Much did I rage when young
> Being by the world oppressed,
> But now with flattering tongue
> It speeds the parting guest.

He was outspoken, frequently irreverent and occasionally quick-tempered, but always transparently honest and totally lacking in malice. His human qualities, his openness, charm and wit made him many friends in Australia and throughout the world.

Ted loved literature and read very widely: biography, history, politics and poetry. We would spend much of our time together discussing the latest books we had read, or recent articles in the *New York Review of Books* to which we both subscribed. He finished reading Boorstin's *The Creators* (a history of the creative arts), a book I had lent him, about two weeks before his death, and had launched into Conor Cruise O'Brien's book on Edmund Burke, which he had received as a Christmas present. He described the latter as being somewhat biased in its views.

Ted had the gift of remembering poetry and quoting it on appropriate occasions. He was particularly fond of W. B. Yeats, and would often quote from his poem 'A Prayer for Old Age':

> I pray — for fashion's word is out,
> And prayer comes round again —
> That I may seem, though I die old,
> A foolish passionate man.

He thought of this as a not inappropriate description of himself.

Ted was very fond of the Australian landscape. He felt very much at home among gum trees, and loved the skyline of the Brindabella hills near Canberra; he was very proud of Australia's landscape painters. He was equally proud of its scientists and Nobel Prize winners, among them Macfarlane Burnet, John Eccles, Howard Florey and Patrick White. He had an enormous enthusiasm for Australia's sportsmen: he would watch cricket or Australian Rules football on television on Saturday afternoons, and if I visited him at that time, would continue to barrack hilariously for his favourite team. He enjoyed hearing and telling jokes, good company and conviviality, and in the evening a single drink of Scotch whisky; I kept a bottle for him in our drinks cabinet, for his occasional visits to our home.

In May 1993, after a lifetime of asthma attacks, which were treated with Ventolin inhalers, Ted was diagnosed as suffering from a slight cardiac fibrillation. He took medication for this, and seemed to have the condition under control. He continued to come to work at the ANU, to collaborate with visitors to the SGS Department of Statistics and the School of Mathematical Sciences, and to hold his usual lively discussions on the economic and political conditions of Australia, the civil war in Bosnia or the unrest in Israel, over lunch. He remained active right up to the afternoon of Friday 7 January 1994, joking with colleagues and remarking on his great good fortune at having enjoyed so full and interesting a life.

Ted Hannan was a distinguished statistician, and an exceptional human being who enriched the lives of all those he touched. He rejoiced in life and all that it had offered him in intellectual achievement and human fulfilment; of him, it could truly be said as in W. B. Yeats' poem 'The Apparitions':

> When a man grows old his joy
> Grows more deep day after day.

His sudden death has left a great gap in our lives: he will be greatly missed by all those who loved him — his wife and family, his friends and his colleagues.

University of California
Santa Barbara,
and Australian National
University, Canberra
11 March 1994

J. GANI

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The Australian Academy of Science Establishes a Hannan Medal for Distinguished Research in the Mathematical Sciences

The Council of the Australian Academy of Science has agreed to commemorate the research achievements of the late Professor E. J. Hannan by the establishment of a Hannan Medal and Lecture.

The medal is to be awarded in the following three areas of the mathematical sciences at two-yearly intervals:

1994 Statistical Science
1996 Pure Mathematics
1998 Applied and Computational Mathematics

The cycle will then be repeated from the year 2000 on.

The award will be made to a scientist for distinguished research carried out mainly in Australia, with special weight attached to recent work. Approval has been requested for the recipient of the award to deliver a public lecture on his/her research at a meeting of the Statistical Society of Australia or the Australian Mathematical Society, depending on the area of the award.

Colleagues and friends of Ted Hannan are invited to contribute to the Hannan Memorial Fund of the Australian Academy of Science. Contributions, for which receipts will be sent, are tax deductible in Australia. Cheques in sterling, US dollars or Australian dollars should be made out to 'The Australian Academy of Science' and clearly marked 'Hannan Memorial Fund'. They should be mailed to

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