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J. A. C. Brown: Early Economic Modelling and Applied Econometrics in the UK*

John Creedy†

Abstract

This paper describes J.A.C. (Alan) Brown's contribution to early economic modelling and applied econometrics in the UK. This involved pioneering work, including the early application of programmable computers to linear programming and optimal diets, demand analysis (including Engel curves and probit analysis), and large-scale economic modelling which integrates National Income accounting methods, input-output matrices, and demand projections. His joint book on the lognormal distribution, its application to a range of economic contexts, and associate estimation problems, written with John Aitchison, continues to be widely cited. His influence, through his undergraduate teaching and graduate supervision, is also shown to be of much value.

*I should like to thank Peter Earl for helpful suggestions, stimulating discussions, and sharing his experience of what passed for supervision in Cambridge.

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1 Introduction

James Alan Calvert (Alan) Brown made important contributions to the development of applied econometric and modelling work in the UK, particularly during the 1950s and 1960s.[1] He was born in Bury, in Lancashire, on 8 July 1922; slight traces of his Bury accent could still be discerned later in life. He attended Bury Grammar School, an independent day school founded around 1570, where Latin was a compulsory subject. He won a Major Scholarship in classics, and entered Emmanuel College Cambridge in 1940, taking Part I of the Tripos in 1942. This year marks a major change of direction, as he joined the army and began his training in Japanese, which led to codebreaking in the Intelligence Corps. Returning to Cambridge in 1946, he graduated in economics. The code breaking work provided an introduction to computers, leading ultimately, via work on the National Food Survey, to his pioneering work in economic modelling and econometric estimation.

The post-war period was one of rapid change in many related areas. The development of programmable computers made possible the application of new sophisticated econometric methods, along with the development of large-scale models. This was accompanied by increasing access to data associated with the concern with diet and food consumption during the war and the long period of post-war rationing. In addition, there had been important developments in national income accounting, also famously stimulated by the war. In particular, from the pioneering work of Stone and Meade, the National Income aggregates were seen in the context of a social accounting framework. This allows the incoming and outgoing entries to be recorded in matrix terms, with an inter-industry input-output matrix as one component. Changes were also taking place in the academic economics profession, which became increasingly more quantitative. The wider range of required skills meant that research more often involved teamwork and joint authorship.

Alan was in the vanguard of all these changes. Given his astonishing analytical and creative powers, his breadth of learning and curiosity, it seemed almost impossible for

[1] There were obviously important developments taking place in the US, such as the work of the Cowles Commission, and the development of macro-models, the Klein-Goldberger model being the prime example. The exchange of ideas was helped by the numerous visitors to the Department of Applied Economics in Cambridge.

him to turn to any topic without taking a fresh approach.

The period also saw an increasing number of graduate students, although this was relatively slow in developing outside a few universities in the UK. This obviously required supervision, and although economics supervision in Cambridge is known to have been almost non-existent, the Department of Applied Economics (DAE) – though not a teaching department – was the exception. In particular, postgraduate students were directly involved in the larger teamwork required for large-scale modelling. In this respect Alan had a significant influence as a supervisor and team leader, with his leadership qualities enhanced by his lively sense of humour.[2]

A complete appreciation of his contribution is complicated by several factors. The relevant period is of course long before the 'publish or perish' environment became the norm.[3] Not all research papers appeared in journals, but often made their appearance in bibliographies under the heading, 'mimeo'.[4] Unfortunately this means that, without a digital presence that would undoubtedly exist today, it is usually impossible to obtain copies. A number of Alan's papers are in this category. A list of publications can be found in the brief memoir by Stone (1985), but he acknowledges that it is likely to be incomplete.

In addition, Alan's influence extended well beyond his own journal and other publications in view of his willingness to help others in numerous ways, to give away valuable ideas and to encourage team work. He simply gave away many ideas for others to work on, as clearly demonstrated by the many acknowledgments made to him in the research output of the DAE. These include the books by Cramer (1962), Bain (1964), Pyatt (1964) and Ironmonger (1972), and for a small sample of papers and books acknowledging his help, see Prais (1953), Prais and Houthakker (1955), Hart and Prais (1956), Stone and Rowe (1957), and Bacharach (1970).

The difficulty of finding unpublished material is compounded by the fact that many of those who worked closely with Alan have died, or otherwise cannot be traced. However, the present account is augmented by my own recollections of Alan as teacher and supervisor. I was fortunate to be one of Alan's students, both as an undergraduate in

[2]While I do not remember him laughing loudly, he frequently chuckled quietly, at interesting as well as amusing things. He always greeted warmly the many people who telephoned or knocked on his door.

[3]He once said, 'Anyone can write papers, but what is really hard is producing papers that others can't afford *not* to read'.

[4]The term is short for a mimeograph paper, which was produced by forcing ink through a stencil. The term continued to be widely used long after papers ceased to be duplicated using such methods.

Bristol and as a graduate in Oxford. Thus, this paper gives a glimpse of Alan as a teacher of undergraduates and as a graduate supervisor.[5] I was certainly too much in awe of him and too diffident to ask personal questions. So it must be admitted that I have only a partial picture of him. Furthermore, although I had the privilege of seeing something of his brilliance and the way he worked, this was not his most productive period.[6]

Section 2 begins by describing Alan's great skill with languages, and its importance for his role in intelligence during WWII. Section 3 discusses his main areas of research. Given the many overlaps, this cannot easily be described in a 'linear' fashion, although it is divided into a number of broad subject areas, beginning with his pioneer computer programming. His work in economics began with the National Food Survey, leading to his association with Richard Stone, and movement in 1952 back to Cambridge, to the Department of Applied Economics. This extremely fruitful period saw his work with John Aitchison on the lognormal distribution and a range of applications in economics, such as Engel curves and the distribution of income. Another major achievement was the Cambridge Growth Project, which he instigated following the insight of combining the Social Accounting Matrix perspective of National Income Analysis, the associated input-output analysis, and modelling the growth of consumer expenditure. Section 4 turns to his period at Bristol University from 1965. The period in Bristol was followed by a move to Oxford in 1970, and his style of graduate supervision is discussed in Section 5. These two sections are necessarily more personal, involving some of my own recollections. However, they demonstrate his devotion to serious teaching and his special, not-to-be forgotten, qualities as a supervisor, involving inspiration and encouragement rather than detailed instructions.

The high period of his career was without doubt the years at the Department of Applied Economics in Cambridge from 1952 to 1965. Here, under the initial directorship of Richard Stone, he found the ideal environment which was shared with other outstanding colleagues. This environment has been described at length elsewhere. For example, Peseran (1991) and Peseran and Harcourt (2001) concentrate mainly on Stone's role, while Smith (1998) concentrates on theoretical econometric work.

[5] Stone (1985, p. 194) says that at Oxford he 'supervised innumerable theses'. I have not been able to obtain details of other students, and so have been unable to discuss my experiences with others he supervised in Oxford.

[6] However, his influence – on virtually every aspect of my work – is impossible to exaggerate.

2 Languages and Codebreaking

A decisive change came in 1942, after two years of studying Classics at Cambridge, when Alan joined the army and learnt Japanese. Under the initiative of John Tiltman, of Bletchley Park codebreaking fame, it was recognised (particularly after Pearl Harbour) that there was an urgent need for people who knew Japanese. Captain Oswald Tuck was brought out of retirement to design and teach a highly intensive course, lasting a mere six months, at the Bedford Japanese School.[7] Those with a classics background were selected for codebreaking work, while those with a modern-language background were chosen for interrogation purposes. Alan is listed on the Bletchley Park web site as being there from mid-1943 as a 2nd Lt in the army Military Wing Intelligence Corps.[8] He also spent time in India and Burma, and Stone (1985) mentions that he finished as Captain in the Intelligence Corps.

Alan only once mentioned his codebreaking work, in discussion some time after I had left Oxford. He commented, with some amusement, that his staff, working long hours under stress, used to insert numerous obscenities into their own coded messages. However, he refused to tell them to stop the practice, despite orders to do so.[9] On an earlier occasion, he mentioned a dinner in Merton College, Oxford, when he was seated next to a visiting Japanese mathematician. Though he knew it was a silly question, he asked the visitor what he did in the war: the answer was that he worked out optimal flight paths for suicide pilots.[10]

His facility with languages was indeed remarkable. He spoke Italian fluently and told me that he learned it by reading the local newspapers while working in Rome with the Food and Agriculture Organisation. He knew Rome better than any city in England, and I had the clear impression that he also preferred being there. In Oxford, Alan clearly enjoyed the company of the Italian graduate students, of which there were many.[11] Alan's international sympathies were obvious. In the early 1970s he organised,

[7] This was referred to as the Bedford Spy School, located at Ardor House on the corner of Dame Alice Street and the Broadway. A Japanese language course was also provided by the School of Oriental and African Studies in London, but this was for two years, which was judged to be too long.

[8] https://bletchleypark.org.uk/roll-of-honour/

[9] Actually, as reported by veterans of Bletchley Park, their inclusion in messages makes it easier for others to break the code.

[10] Alan's final published paper, in the year of his sudden death, was the joint 1984 paper, with Angelina Helou, on fiscal policy in Japan.

[11] He mentioned touring Italy with John Hicks, to encourage students to go to Oxford. He once took my family to lunch in Oxford in an Italian restaurant, where he spoke fluently with the waitors and was entusiastically welcomed by them.

with Harry Johnson and others, the collection and distribution of books to be sent to Bangladesh. When one of his overseas students became short of money, Alan helped to set him up, in his garage, running a bicycle repair business.

When Alan was doing some modelling work for the Bank of Iran in the mid-1970s, I asked if he planned to learn the language. He replied that he wasn't yet sure which one was appropriate, but that he might spend August to learn. This was purely a 'matter of fact' statement and I really do not think he felt there was anything special about it. The work arose from his friendship with Hassanali Mehran, who at the time was Chief Economist at the Bank of Iran, and subsequently worked in the US for the International Monetary Fund. Mehran had previously spent time at Bristol University as a research assistant and then lecturer. Alan's work for the Bank of Iran obviously came to an end after the 1979 revolution, but it led to several papers published in the *Oxford Bulletin of Economics and Statistics*.[12]

For the Royal Economic Society conference on income distribution, held in Lancaster University in 1974, and which he helped to organise, Alan presented his paper on statistical models of income distribution.[13] As the discussant pointed out, this was distinguished by the fact that it did not include a single equation, but it did include his own lengthy translations from Greek, Latin and Italian. In additon, Alan published a paper in French, on the concept of saturation levels in the Engel curve context. He insisted that I should use the Greek letter, theta, to denote a death rate because the Greek for death is thanatos.

3 Main Research Areas

Alan's Japanese codebreaking in WW2, and the consequent exposure to Hollerith machines, brought about a move into economics and work on the statistical analysis of household expenditure data. And of course it is well known that the war stimulated the development of programmable computers.[14] In view of Alan's pioneering use of

[12]Stephen Powell, then at the Oxford Institute of Economics and Statistics, told me that the modellers in Iran had failed, after some weeks, to get their computer program to run, but Alan fixed it in one day.

[13]In addition to the income distribution modelling in *The Lognormal Distribution*, Alan told me that he once wrote a paper on the distributional implications of relative price changes. However, Harrod rejected the paper, submitted to the *Economic Journal*, on the grounds that it was 'politically sensitive'. I have been unable to trace this paper.

[14]The first programmable computer was the Colossus, of which several were built over the period 1943-44 for use by Bletchley park codebreakers. The Colossus owes its existence to Tommy Flowers

computers in applied economics, this section begins by discussing aspects of this early work. This is followed by brief descriptions of his work on consumption and demand analysis, the lognormal distribution, and the Cambridge growth project.

3.1 Early Use of Computers

Alan's move to the DAE gave him access to the first UK stored program computer, the EDSAC (Electronic Delay Storage Automatic Calculator), developed at Cambridge by the team directed by Maurice Wilkes. This was the first computer to be used for academic research, from around 1951. And, as mentioned above, he also had access to the Ferranti machine at Manchester for the work on linear programming. Alan's first journal paper, published in 1953 and written with Houthakker and Prais, seems to have been the first to describe the use of the computer as a research tool. This experience involved programming in machine code, and Alan told me that this led to him knowing by heart many of the powers of 2.

A valuable contribution to the work of the DAE was his role in getting Lucy Joan Slater involved in programming.[15] In a later interview about her role in the early use of computers in Cambridge, Slater (2012) explained that:

> Actually I ought to say a bit about applied economics. There was a fellow called Allen [sic] Brown, and he was fairly high up in applied economics; he was the second from the top in Economics. He used to come in the Lab sometimes ... He said to me, Could I help him? I'm always ready for a few bob on the side, you know, cash in my pocket, and I said 'Yes'. So I did some work for them.

Alan also wanted to start a proper computing unit that could prepare programs and the data to run on EDSAC II. Slater's comment on her subsequent interview nicely illustrates the general ignorance regarding computing at the time:

> ... there were two old men there who were very senior economists. I said that I needed somebody to help me with the punching. Punching paper tapes was what I meant, and most of the people around the interviewing

(1905-1998), working to a design by the mathematician Max Newman. After the war, Newman established the Royal Society Computing Machine Laboratory at the University of Manchester.

[15] Alan also gave programming help to Rex Bergstrom during his his pioneering work in Cambridge; see Phillips and Hall (2004, p. 131).

> board — Allen [sic] Brown, Richard Stone — right away knew what I meant, but Professor [Sir Dennis Holme] Robertson didn't. He was a generation before them. He looked horrified, and he said, "Do you mean you have to fight to get your own work done?' I couldn't understand what he was talking about. The other men laughed, and then somebody explained to him that it was paper tape, and it was punching holes in paper tapes!

Slater, with Michael Farrell, went on to create early econometric software, including regression and matrix manipulaion programs, for EDSAC. After Fortran was introduced in 1957, Slater in the 1960s wrote Fortran versions, and produced two volumes; see Slater (1967, 1972). At the time, no 'off the shelf' software was available, so these books proved to be useful aids to those starting to write in Fortran.

Perhaps not surprisingly, in the early 1980s Alan became very keen on the new microcomputers and was developing some econometric software for regression and time-series analysis. I was given an early enthusiastic demonstration of this, my first exposure to a microcomputer.[16] This also led to a late paper on estimating the Lorenz curve and Gini, written with Giuseppe Mazzarino, a research assistant at the Oxford Institute.

3.2 Consumption and Demand Analysis

After Alan returned to Cambridge in 1946 to graduate in economics a year later, he moved to the statistical division of the Ministry of Agriculture Fisheries and Food.[17] The ministry was responsible for carrying out the National Food Survey, NFS, which began in 1940 with the aim of investigating working class diets. Alan was involved with the annual survey for many years until his death. He is listed as a member of the NFS Committee on all annual reports from the 1961 to 1983 surveys, and his contribution to the estimation of elasticities is acknowledged in NFS reports; see, for example, NFS (1958, p. 26; 1963, p. 33). This work also led to his pioneering contribution to covariance analysis. Despite the fact that this was used in many later reports, it was

[16] He had also written an introduction to microcomputers, with a useful glossary of terms. This also appears to have been lost. I'm pretty sure the machines he was using were marketed by an Oxford company, Research Machines (RM), started by Mike Fischer and Mike O'Regan, and which in the 1980s began selling microcomputers to the education sector in the UK.

[17] Alan told me that, unlike a number of his codebreaking colleagues, he did not want a career related to Japan, as he did not want to live there.

never published in full. However, Stone (1985, p. 196) lists his unpublished paper for an FAO/ECE Study Group on Demand for Agricultural Products.[18]

His early research, encouraged by W.L. Kendall, concerned the connection between diets and food consumption. Stone (1985, pp. 191-2) has described this early innovative work in minimum cost diets, involving the use of linear programming methods.[19] This involved pioneering programming of the simplex method on the Manchester Ferranti computer, and using a survey of 1000 working class households. Here, there is an interesting link with codebreaking, as the associated conference organised by Ferranti was chaired by William Gordon Welchman, later made famous by the publication of the story of his wartime work in Bletchley Park. The Ferranti company, after work on defence electronics, produced their Mark 1 computer, completed in 1951. [20]

It was the work on family budgets and demand analysis that brought Alan into contact with Richard Stone, who at the time was working on his major studies with Alan Prest and Deryck Rowe, in association with the National Institute of Economic and Social Research. This involved what was famously referred to as 'Stone age computing', carried out by a team using electronic desk calculators.[21] This contact led directly to Alan's move in January 1952 to the Department of Applied Economics (DAE) in Cambridge. This was initially meant to be for one year only, but it marks his permanent transition to academia.

It is not clear when he aquired knowledge of mathemathical statistic and optimisation methods, but most likely it was very rapid and mainly self-taught. Joint proficiency in classics and mathematics is of course common. In his report of DAE activities from 1951 to 1953, Richard Stone mentions spring-1952 classes on matrix algebra using Aitken's book, *Matrices and Determinants*. He reported that there were nine meetings and two talks on the use of matrices in social accounting. This was all taken very seriously: in the late 1970s, in the National Institute, I showed Sig Prais

[18] I was given a photocopy of this by Alan, but it is not generally available.

[19] Alan mentioned this work to me only once, saying that optimal diets did not reproduce the extent of variety found in budget surveys. Linear programming became, during Alan's time there, a significant component of the Bristol degree in Economics with Statistics.

[20] Their later Atlas computer first ran in 1962, following the Mercury of 1957. London School of Economics had Atlas, although by the late 1960s Dennis Sargan's LSE graduates were using the IBM machine at UCL. A modified version of Atlas, later produced for Cambridge, was the Titan, or Atlas 2.

[21] When I was working at the National Institue in the late 1970s, several of the women who had carried out some of this work for Stone clearly regarded it as a high point, and had fond memories of it.

an equation involving awkward nested summations, and he immediately sent me to an elegant result in Aitken's book that suited the task perfectly.

The subject of demand analysis provided a strong thread through all his work. Other early work, partly in association with John Aitchison, involved the use of the lognormal distribution function to model Engel curves, and the introduction of the concept of a saturation level. This led to a number of contributions to the analysis of consumer durables and new commodities, and here his direct strong influence on the books by Cramer (1962), Bain (1964), Pyatt (1964) and Ironmonger (1972) is also clear.

Mention should be made here of his much-cited survey paper on demand analysis, with Angus Deaton as co-author, that appeared in the *Economic Journal* in 1973. This actually began life as a handout, written by Alan only, that was given to University of Bristol third year students, and later to Oxford graduates. Before it was published Alan told me, with much amusement, that Reddaway (then editing the *Economic Journal*) did not want to publish the paper because of its substantial use of matrix algebra. Richard Stone recommended that a recent Cambridge PhD student, Angus Deaton, could be brought in as co-author. The final result was of course no less mathematical, but Reddaway was then in no position to refuse to publish. Following the publication of the survey, the Royal Economic Society held a one-day conference on demand analysis, which attracted many experts in the field.

3.3 The Lognormal Distribution

In a DAE report for 1951-1953, Stone (pp. 10-11) refers to early work on the Lognormal distribution, started jointly by Alan and John Aitchison. Reference is also made to a paper by Alan on 'Notes on incomplete data in economic statistics', which I have been unable to trace. The report also mentions that Alan's *Econometrica* paper on the consumption of food was presented in 1953 to the Innsbruck meeting of Econometric Society. Also, he presented a paper in March 1953 to a meeting of the Royal Statistical Society. At the time, Stone was on the editorial board of *Metroeconomica*, which may explain why some of Alan's early papers on the lognormal and income distribution were published there. Alan told me that he and John Aitchison began working on the lognormal while Stone was away from Cambridge, and by the time he returned they had done enough to convince him of its value.

This work eventually led to the jointly authored book, referred to simply as *The Lognormal Distribution*, published in 1957, for which Alan is probably best known these days.[22] It continues to be widely cited and has perhaps reached the point of being a 'classic' in the econometrics literature.[23] This was a pioneering volume in devoting a whole book to a single distribution, but it was very much broader in scope, as indicated by its full title: *The Lognormal Distribution with Special References to its Uses in Economics*. In particular, it provided pioneering studies of the use of probit analysis, covering quantal and quantitative responses. This was in the context of Engel curves, consumer durables and new commodities. It was several decades before probit analysis became widespread: it is now of course ubiquitous in applied econometrics work. In this Engle curve context, *The Lognormal Distribution* also contains some interesting analytical results regarding aggregation.

This book was thus also a pioneering volume in nonlinear econometric methods, particularly in the probit analysis context. It devoted considerable attention to iterative maximum likelihood methods based on Fisher's famous 'method of scoring'. This involves, when using Newton's method of solving nonlinear equations, replacing the matrix of second derivatives of the likelihood function with expected values, often involving a considerable simplification and computational saving. The convergence properties of iterative methods were examined in detail, including the problem of how to choose initial values. This kind of work would of course not have been possible without access to mainframe computing facilities, given the iterature nature of the necessary computations. The book therefore also reflects pioneering work in computer programming in econometrics discussed above, making use of the unique computing facilities in Cambridge during the early 1950s.

The Lognormal Distribution book is noteworthy for its discussion of the historical development of the statistical methods involved, and its attention to the stochastic processes capable of generating the form of the lognormal distribution, rather than simply adopting a convenient approximation. It is also the only econometrics book I

[22] In the same year he published a paper with F.C. Rodger in Transactions of the Royal Society of Tropic Medicine. While this may seem surprising, it simply reflects his broad interests and keeness to apply statistical methods. The authors acknowledge W.L. Kendall, then Chief Statistician at the Colonial Office. Of course W.L. Kendall was a friend of JACB and, as mentioned above, provided encouragement in his early days working on the National Food Survey.

[23] A more recent edited volume of papers concentrating on the lognormal distribution and applications is Crow and Shimizu (1988). Surveys of applications in particular areas include Limpert *et al.* (2001) and Singh *et al.* (1997).

know that has a perfectly apposite quote from Shakespeare at the head of each chapter.

As mentioned briefly above, work on the lognormal also involved its application to income distribution modelling. The three-parameter form of the distribution was also discussed, along with appropriate estimation methods. Alan also encouraged other researchers who were applying the lognormal to the size distribution of firms. One of these, Peter Hart, has left the following description of Alan, which provides some indication of the enthusiasm generated by this work.[24]

> In 1955 [Alan] sent me a home-made carboard rosette, modelled on rosettes given to prize winners at gymkhanas. He attached two pieces of punched computer tape as ribbons. In the centre of the rosette was the lognormal distribution inside a giant capital Greek lambda. Around the circumference he had printed 'Member of the Ancient Order of Lognormalists'. This was his way of thanking me for my presentation of an early version of Hart and Prais (1956) to an NIESR seminar which he attended along with many other stars. I was very proud to receive this rosette and kept it for many years. That is how I want to remember him – brilliant and full of fun.

3.4 Cambridge Growth Project

There is no doubt that a major legagy was Alan's role as the originator and driving force behind the Cambridge Growth Project. Starting in 1960, this was a pioneering model in a number of ways. Basically, Alan suggested combining three strands of the DAE's research in the 1950s. The first are the national accounts. Second, there is the input-output table that is part of the social accounting matrix (SAM), and which provides the framework for double-entry accounting. Third, there is the modelling of consumers' expenditure on the different commodity groups, and associated differential growth. Based on a SAM of the economy in a base year, and using projections of expenditure growth for the commodity groups, projections can be made using assumptions about the SAM in future years. Of course, the projections have to be consistent with investment and capital growth. The computation of adjusted SAMs was explored in detail in the 1970 book on biproportional matrices by Michael Bacharach and here

[24] This comes from an email sent to me by Peter on 13 July 2007.

Alan's important role was acknowledged.[25]

Peseran and Harcourt Peseran (2000, p. 158) describe the birth of the growth project as follows:

> When Alan Brown and Dick [Stone] started the Cambridge Growth Project, they had in mind a model which allowed the expenditure and production interdependencies of the British economy to be tracked over the medium to longer term under different possible scenarios. Its origin was Alan's suggestion that they pull together the DAE's work on social accounting, input-output, and consumers' behaviour to build such a model of the British Economy.

Such an ambitious programme requires considerable teamwork and coordination, and many graduates worked on this model as they passed through the DAE, as demonstrated by the list of publications associated with the project. The project has had remarkable longevity, reflecting the ability to respond to new developments in econometrics, modelling and software. In reviewing the model, Ball (1963, p. 190) commented that, 'Whatever the outcome, there is little doubt that the work of the Cambridge group stands as the major event in British quantitative economics since the Second World War'.

Finally, it is worth adding Stone's (1985, p. 194) comments on Alan's characteristics that contributed to much of the success of the growth project:

> ... the successful launching of our venture and the productiveness of the group in those early years were in large measure due to his drive, enthusiasm and devotion to work, qualities made even more effective by his sweetness of temper and his sense of humour.

3.5 Later Years

Alan's later years in Oxford were marked by ill health. Naturally his output declined, though he continued to be productive. Stone (1985) lists a number of papers published over this period, though they could not be expected to have the impact of his earlier work. He spent significant amounts of time overseas, including trips to Iran, Saudi

[25] This involved the so-called rAs method, where r and s respresent vectors of row and column adjustments to the input-output matrix, A.

Arabia and Egypt, where he advised on the construction of planning models. He was also associated with the large ILO study of Sri Lanka. He was also writing a book on social accounting models, but it was not completed and, sadly, the whereabouts of the draft are unknown.[26] Stone (1985) reported that in the 1980s Alan had been making translations of work by the Italian mathematicians Fibonacci and Pacioli. Like the social accounting draft, this work appears to have been lost.

4 Undergraduate Teaching in Bristol

In 1965 Alan was appointed to a newly created Chair in Econometrics in Bristol. This appears to be only the second econometrics chair in the UK, following the promotion in 1964 of Denis Sargan at London School of Economics. Peter Hart told me that the Colston Society Symposium, resulting in Hart *et al.* (1964), was organised largely to attract Alan to Bristol. It also contains an important paper by Sargan. Stone (1985, p. 194) suggested that after moving to Bristol, Alan 'revealed himself as a teacher of almost apostolic fervour'. Certainly, within a short period of time, he had a great influence on the department, its standards and the structure of the degree.

He gave a first-year course on National Income accounting.[27] I still have the superb handout that he produced to accompany the course. As might be expected given his work on the Cambridge growth model, his course on National Income Accounting was much more than a treatment of the formalities of the 'Blue Book' and the 'Red Book', both of which we had to purchase. The course provided the foundation of the SAM (Social accounting Matrix) approach which, as mentioned above, is fundamental to the growth modelling at the DAE. Compared with the other first year lectures in economics in Bristol, this material was much more advanced and was, I suspect, unique in UK universities. Later in the year, his lectures were sometimes taken over by Hassanali Mehran, when Alan was away at the United Nations discussions set up to agree on the new System of National Accounts, SNA, issued in 1968, in which Richard Stone obviously played an important part.

Students taking the degree in Economics with Statistics took second and third year

[26] I read draft material in hand-written form. When I asked some time later how the book was going, he said that the main task to be completed involved dealing with the relationship between Sraffa's work and input-output analysis. I have the impression he had a contract with Oxford University Press.

[27] Reflecting the more formal nature of universities at the time, he appeared at the first lecture wearing a gown. Gowns were worn for dinner in the halls of residence.

courses in optimisation methods. These contained extensive treatments of linear and nonlinear programming, with of course the simplex method taking a prominent place. It seems highly likely, given his pioneering use of linear programming, that this was influenced by Alan.

In the second year Alan gave the first term's lectures on distribution theory to those taking the degree in economics with statistics. These lectures were hard going: the recomended text was volume one of Kendall and Stuart. During each hour Alan repeatedly covered the blackboard with equations and then wiped it clean.[28] However, it was a superb and well-structured course, and provided an invaluable foundation for a great deal of later work. Again he also provided a carefully prepared handout. At the time, a number of second and third year courses were taken by MSc students. After one lecture, an MSc student taking the course approached Alan and suggested that some of the students were finding it very difficult. He said quickly, 'then they shouldn't be here'. I'm sure this comment reflected his irritation with the particularly annoying graduate, rather than any general lack of sympathy.[29]

In the third year Alan gave a superb course of lectures on demand analysis. Apart from the technical details, his sympathetic attitude taken towards earlier contributions made an impression on me. He always encouraged work in the history of economic analysis, particularly early mathematical and statistical work. Again we were given a substantial handout, and he later repeated this course to graduate students in Oxford. As mentioned above, this was the basis of the celebrated joint *Economic Journal* survey with Deaton.

When discussing undergraduate teaching, it may be worth quoting the following comment by Alan. When I was leaving Oxford to go to my first lecturing position, Alan's parting advice was, 'don't forget that most students are not as enthusiastic as you are'. Like many valuable lessons, it takes some time to absorb this one fully.

[28] While taking the course, I suddenly realised a valuable lesson: I had heard no stories of previous failures, so if I just carried on working hard, there should not be any problems.

[29] Peter Hart and I later came across this person, while working on a project financed by the Department of Health and Social Security. Another DHSS person involved had previously been taught by Peter. We both had cause to be irritated by them.

5 Graduate Supervision in Oxford

Following advice from Richard Lecomber, who arrived in Bristol from Cambridge at the start of my third year, I went to see Alan about possibilities for graduate study.[30] Alan suggested that the best course of action was to apply to do the BPhil at Oxford. At the time virtually all 'masters' courses were for one year only, and PhDs in the UK typically did not include any coursework. The BPhil involved four examination papers at the end of two years, with a substantial thesis. It provided a very good basis for an academic career: at that time a PhD was not required to obtain a lectureship in the UK.

Shortly after receiving my offer from Balliol, I heard that Alan was going to Oxford to take up a Chair at Merton College. This was indeed a major stroke of luck for me. Alan later told me that he wanted to leave Bristol as a result of the problems associated with the student protests and occupation of the administrative buildings during 1969. He knew one of the student leaders (I believe it was an economics student) and approached the Vice Chancellor with the aim of holding a meeting. The VC simply refused to talk and from that moment Alan decided to move.

In other respects Bristol suited Alan well and his family was settled there. In retrospect the move to Oxford was for him probably a bad decision. The Oxford Institute of Economics and Statistics did not provide the kind of environment in which he would be most comfortable. It was simply a place where some people had offices and where there was a superb library. A properly operating Institute, with plenty of interaction among the members, would have been a more suitable environment. When I later asked him about the directorship of the Institute, Alan suggested that an ideal person would be someone aged in his mid-40s with too many ideas to explore himself and keen to pass them over to others, often working in small teams. Of course, he was really describing himself during his time at Cambridge.

Soon after arriving in Oxford, in late 1970, Alan suggested that it might be a good idea for him to supervise me. I came to realise that supervision is the most important aspect of a graduate's work and that I was very lucky. Other students used to talk about their supervisors, mentioning their meetings once or at most twice each term, which largely seemed to be a waste of time. I was able to knock on Alan's door at any

[30] Richard was very stimulating, encouraging, sympathetic and enormously helpful. He died, relatively young, of a brain tumour. Alan's first wife also died of a brain tumour.

time and he was always prepared to listen. Whenever I showed him anything, his first question would usually reveal how far ahead he was. It was often a case of listening very closely, and storing hints to follow up later.[31]

The role of the supervisor was particularly important in view of the complete absence of any systematic teaching, despite the fact there were subjects to select and examinations at the end of the second year. No syllabus, or even reading list, was ever available and even though some lectures were given, they were seldom worth attending.[32]

The research seminars in Nuffield also provided a valuable education, where it was possible to listen to many famous visiting speakers. BPhil students, especially in their first year, were not supposed to attend, but as I never said anything and often went in with Alan (a further demonstration of his encouragement and support), there was no problem. Alan seldom spoke in these seminars, but on the occasions when he gave me a lift back to the Institute, it was fascinating to hear his clear and succinct statements of the main issues and difficulties.

Alan organised a series of seminars in the Oxford Institute. Richard Lecomber came from Bristol to give a paper, but had not arrived by the scheduled time. After a few minutes Alan decided to start, without notes of any kind, to talk about the topic. After a further ten minutes or so, Richard, who had been delayed with a puncture and had not even had time to clean his dirty hands, rushed into the room and took over without any hesitation. During question time, Alan asked if anyone had considered trying a particular approach. Richard hesitated for a moment and then said, 'well yes, *you* have' and reminded us of the results. At the time it amused people that Alan had forgotten, but it now does not surprise me at all.

His way of getting me to begin taking a proper research approach was to mention particular problems in his own work.[33] I took the hint, and would go away, only to

[31] Not surprisingly, one conversation with Alan turned to the subject of Richard Stone. I suggested that Stone must have been very quick, but Alan contradicted this and described Stone's work habits (these have also been described by Deaton, quoted by Smith, 1998). Alan mentioned returning home at breakfast time after working all night with Stone on drafts of the growth project reports – mostly disputing commas. Alan said that he had actually written two of Stone's papers. This was neither a complaint nor a boast, as he clearly admired Stone greatly, but I foolishly did not ask which papers they were.

[32] The outstanding exception was Max Corden, about whom I've written elsewhere.

[33] I began by writing a couple of essays, with the subjects taken from previous BPhil examination papers. Alan soon put a stop to that with the comment, 'these are very good undergraduate essays', with the emphasis on the word 'undergraduate'. It was time to do real research.

return when I thought I had something I dared put in front of him. I think that if I had not responded to such suggestions, he simply would not have bothered with me. At an early stage he said, while handing me a book and without any great emphasis, that I should learn Fortran programming, which of course I did immediately. Again, it was simply something that was expected, not worthy of any special discussion. The advantage of this advice is impossible to overstate, but it meant that for a long time I did not realise how rare it was for economists to write programs.

Early in the first year of the BPhil, Alan met with those people who had selected applied econometrics as one of their optional subjects, divided us into groups, and distributed a number of topics.[34] I was paired with an Italian student and we were given some notes on the model of age-income profiles that made a brief one-paragraph appearance in *The Lognormal Distribution*. Further progress clearly required finding some suitable data – not easy at that time – and writing a computer program to carry out the maximum likelihood estimation. I was not surprised when Alan later told me that the other student had shifted to another topic. We decided that I should continue on my own and that it might well form the starting point of work for the BPhil thesis. He passed me a thin folder with some further notes, including some useful early references, and advised me that, although most students started the thesis in the second year, it would be a good idea to work on it in the first year and complete a first draft over the summer. This was invaluable advice.

When I mentioned that I was planning to start writing up my work, he asked to see a detailed table of contents. I was rather surprised and replied that it would be difficult as I had not actually started. He simply said something like, 'yes, it might take a few days' and indicated that it would nevertheless most likely undergo changes as the writing proceeded. This clear signal that it was not a trivial task and should be given high priority also proved to be invaluable advice. I showed Alan the completed draft before having it typed. He did not comment in detail or write corrections on the draft, and I knew better than to expect more. But he was quietly encouraging. His approach to graduate supervision did not follow the kind of instructions given in handbooks produced these days by the education departments of universities, describing what a model of supervision looks like. He did not edit work, or set out clear lists of expectations or discuss written plans in scheduled meetings. Instead, he provided a

[34] I think there were further meetings to consider progress or problems, but it was the only one that I can remember attending.

most valuable and rare kind of leadership by example, with subtle hints and quiet encouragement. He was always available for discussions.[35] A brief meeting, reinforced by reading and re-reading his own papers, provided all the stimulus one could hope for.

6 Conclusions

This paper has traced the career of Alan Brown and his major pioneering contributions to economic modelling and estimation. A crucial factor was timing: in WWII the diversion from classical studies to learning Japanese, and thence to work on code-breaking, was followed by a shift to economics and initially to work in the Ministry of Agriculture, Fisheries and Food. This work led to pioneering contributions involving linear programming (to examine optimal diets), covariance analysis and demand analysis. Here, the wartime stimulus toward substantial developments in programmable computing played an important role. Similarly, the need for information about working class diets under a prolonged period of wartime and post-war rationing led to the introduction of regular household surveys, which greatly expanded the range of empirical analyses which could be carried out. The movement, under the influence of Richard Stone, to the Cambridge Department of Applied Economics resulted in his most productive time. It gave him a congenial environment and access to the Cambridge computer. Work on demand analysis, particularly the study of Engel curves, yielded innovative work on probit analysis, many years before it became widespread in economics. Associated with this was the work, with John Aitchison, on the lognormal distribution and its application to other contexts, particularly income distribution modelling. The book on the lognormal distribution has become a classic, but another high point of Alan's time at Cambridge was his stimulus and contribution to the Cambridge growth project, which has had such great longevity. The modelling approach was later adopted to analyse a wide range of other countries, which involved Alan in a certain amount of consulting work.

Given the wide-ranging aspects of such large-scale projects, a new aspect of the work at the Cambridge DAE was that it often involved teamwork and joint publications, which were unusual at the time and did not become widespread until very much later

[35] He never turned me away or discouraged our meetings, but I began to feel that I was taking up too much of his time, and reduced the frequency of meetings somewhat. However, I have come to realise that I do not mind how often or how long my graduate students call to see me.

– indeed not until commercial computer software, microcomputers, and large scale datasets became readily available. Alan was heavily involved in such team work, and was happy to give a substantial start to get younger colleagues working in innovative directions. However, an unfortunate implication of the lack of a publish-or-perish mentality at the time meant that some of Alan's work did not get published in easily accessible form.

This paper has also discussed Alan's contributions to undergraduate teaching and graduate supervision. In his lectures in Bristol university he was unusual in introducing students to the very latest contributions, often involving his own work – although given his modesty this was not likely to have been recognised by most students (particularly given the nature of his extensive handouts). His qualities as a supervisor in Oxford were seen to be exceptional, involving inspiration and encouragement. As stressed by Richard Stone, his personal qualities, enthusiasm and sense of humour played a large role in stimulating further research. He led by example.

It has been seen, not surprisingly, that Alan's work was in some sense 'of its time', in that there are clear links with the intelligence work carried out in WWII, the associated developments in computers, and the need to survey household diets. Similarly, the post-war environment, following catastrophic destruction and transformation of economies, was one in which there was an impetus to develop planning models, and here Alan's response in terms of the Cambridge growth model stands out. Yet the value of his contributions has extended well beyond such confines, with a longevity that is evinced by the continued references to *The Lognormal Distribution* and the application of various types of social accounting matrix (SAM) methods to a range of developing countries.

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