

# Life and Work of John Richard Nicholas Stone 1913-1991

M Hashem Pesaran  
Trinity College, Cambridge

and

G C Harcourt  
Jesus College, Cambridge

March 1999

## **Abstract**

Sir Richard Stone, knighted in 1978 and Nobel Laureate in Economics in 1984, was one of the pioneering architects of national income and social accounts, and one of the few economists of his generation to have faced the challenge of economics as a science by combining theory and measurement within a cohesive framework. He was awarded the Nobel Prize in Economics for his “fundamental contributions to the development of national accounts”, but made equally significant contributions to the empirical analysis of consumer behaviour. His work on the “Growth Project” was also instrumental in the development of appropriate econometric methodology for the construction and the analysis of large disaggregated macroeconomic models. This paper provides an analysis of Stone’s many contributions.

**Keywords:** National income accounting; Consumer behaviour; Macroeconometric modelling.

**JEL Classification:** B3, C8, E2 O4

## Life and Work of John Richard Nicholas Stone 1913 – 1991<sup>1</sup>

John Richard Nicholas (Dick) Stone was born on 30 August 1913, the only child of Gilbert and Elsie Stone. His father was a distinguished lawyer. The family was a happy one; Dick had great affection for his parents, always wishing to please them and distressed if he had to upset them. He was always a kindly, loving and considerate person for whom personal clashes were traumatic events to be avoided if at all possible. This did not, however, mean that Dick would give in or could be diverted easily from the course that he had set himself. He had the typical education of an English upper middle class boy of that time – a prep school (Cliveden Place) followed by a public school (Westminster) where he did classics. His future brilliance was *not* in evidence at his secondary school because he was not taught the subjects which would have interested him – mathematics (past school certificate), and science.<sup>2</sup> He was therefore overcome with boredom for most of his secondary school days. So when his parents went to India in 1930 – his father had been appointed a High Court judge at Madras – Dick went too. When his father asked the headmaster “What are we going to do about Dick?”, he replied “I should take him with you, he doesn’t seem to be doing much good here”. So in the year between school and university Dick “danced, played tennis, and travelled a bit round India [Malaya, Singapore and Java] ... all highly enjoyable.” (Pesaran 1991, 87).

He went up to Cambridge in 1931, to Gonville and Caius, and read law for two years,

---

<sup>1</sup>In writing this obituary article we have been greatly helped by reading, in addition to Stone’s own writings, the excellent accounts of his work given by Leif Johansen (1985) and Angus Deaton (1987,1993). We have also drawn on two examples of oral history with which the authors are associated: Pesaran (1991) and Harcourt (1995). We are most grateful to Lady Stone for allowing us to look at Dick’s correspondence, and for her general help and advice.

<sup>2</sup>It is a remarkable achievement that his papers are noted not only for their emphasis on quantification and measurement but also for innovative and difficult (in the Frisch sense of not dodging difficulties) mathematical analysis. Stone acquired these techniques as an avid reader and from discussions with friends who were good mathematicians.

getting firsts in the Tripos Exams but not enjoying the subject. In his second year, 1932-33, he says he did “a foolish and rather unkind thing”. He “was determined ... to switch to economics [so he] never opened a law book after Christmas 1932 [but] read Irving Fisher, Marx, Freud, Lenin and popularized science.” (Pesaran 1991, 87). As with many other idealistic young people of that time, he was appalled by the high level of unemployment and wanted to know what caused it and what could be done about it: “Youthful inexperience and innate optimism [made him] think that if there were more economists, the world would be a better place” (Pesaran 1991, 88). So, despite his parents’ disappointment, he read economics for the next two years, again getting firsts and this time enjoying his studies. Caius then did not have an economics fellow so Stone was supervised by Richard Kahn at King’s and J.W.F. Rowe at Pembroke in his first year and by Gerald Shove at King’s in his second year. He thought Richard Khan and Joan Robinson were the best teachers on the theoretical side, but it was Colin Clark who had the “greatest influence” on him. Colin Clark was teaching statistics to economists in Cambridge and captured the imagination of young Stone who believed the economics that was being taught was insufficiently quantitative and found Colin Clark’s work on the measurement of the national income a breath of fresh air. Dick and Colin became great friends; “possibly the first of the many economists who were to be counted ... as close friends”. (Pesaran 1991, 88). A gift for close friendship was one of Richard Stone’s most outstanding and attractive traits.

One of the exercises Dick carried out as an undergraduate was to estimate the parameters of a Cobb-Douglas production function (it was his “first calculation of a least-squares regression ... carried out on a small Monroe ... a twenty-first birthday present [from his parents]” (Pesaran 1991, 89). He tried to explain his procedure to Pigou. When he finished, Pigou “not unkindly” said: “Doubtless it is all very interesting but I still don’t understand. Goodbye, Mr Stone, come and see me again. Always glad to help” (Pesaran 1991, 89). In his final year (1935) the examiners were Pigou, Guillebaud, Austin Robinson, and Hicks. Dick obtained a first along with four others that included David Champernowne and David Bensusan-Butt.

After graduating, because he was sorry that he had upset his parents by reading economics (the first serious clash he had ever had with them), he went into the City, working as an insurance clerk at C.E. Heath and Co., Lloyd's Brokers. He "learned the business and a good deal about life, but [he] never should have become a businessman", and he eventually persuaded his father of this. (Pesaran 1991, 90). Nor did he sever his link with economics. Through Clark, who left for Australia in 1937, Dick and his first wife, Winifred Mary Stone (who, as W.M. Jenkins, had graduated in economics in the same year as Dick) took over the production of 'Trends', a feature in the monthly *Industry Illustrated*, for nearly two years, [2,4,7].<sup>3</sup> This entailed producing each month graphs of British economic time series with commentary as well as specialist articles on virtually anything and everything. In 1938 the Stones published one of the first articles to provide empirical estimates of the marginal propensity to consume and the multiplier, [3]. All this work was combined with an active social life, giving their own dinner parties and being greatly in demand as guests at other people's tables.

Partly because he was known for his writings in 'Trends', when the Second World War became imminent, Dick was asked to join the Ministry of Economic Warfare, which he did at the outbreak of war on 2 September 1939. He was given the task of tracking the imports of neutral countries. This led to him making one of the most accurate predictions in the history of economic forecasting – only to have it ridiculed and himself reprimanded by "the Italophile section of the Foreign Office" (Pesaran 1991, 91). In May 1940 he noticed that all Italian oil-tankers were making for neutral ports around the Atlantic. Dick calculated that they would have reached their intended destinations by June 10<sup>th</sup> and predicted – correctly – that Italy would declare war on that day. The Foreign Office response: "Unfounded suspicions...Italy is a delightful country ... firm friend ... a catholic country [which] needed a lot of paraffin for altar candles" (quoted in Deaton 1993, 3).

A more congenial task offered itself the following year. Austin Robinson had been much impressed by Keynes's *How to Pay for the War* (1940) and felt that detailed national

---

<sup>3</sup> The numbers in square brackets refer to Stone's publications included in Pesaran (1991, 112-123). An updated list is appended to this obituary for convenience.

accounts should be constructed as an essential part of planning wartime production and running the economy when the war would be over. He persuaded Edward Bridges, the Secretary to the War Cabinet, to authorise him to recruit two people to give these ideas a concrete form. James Meade, working at the Central Economic Information Service of the War Cabinet, had already made a start on the job, but he needed someone “to fill in the figures” and so Dick was brought in. Meade and Stone came together in August 1940 and their collaboration resulted in the tables which were circulated as a White Paper (Cmd.6261) with the 1941 Budget, followed by the famous *Economic Journal* article, “The Construction of Tables of National Income, Expenditure, Savings and Investment”, [8]. It also marked the outset of a friendship that lasted until Dick’s death. Angus Deaton (1993, 4) writes: “Although the original conceptual framework was [Meade’s], the process of converting the theory into reality raised an endless series of conceptual as well as practical questions [thereby creating] a joint enterprise in which neither man could ever separate his contribution to the whole”. A detailed account of the collaboration between Meade and Stone is given in [45].

Stone also came to know Keynes well during the war. After the 1941 budget the Economic Information Service was split into an Economic Section (to which Meade went) and a Central Statistical Office (CSO). There Stone was responsible for the national accounts despite the Director’s attempt to put him onto oil statistics which Keynes “stopped” by taking Stone on as his assistant. He produced estimates of national income and expenditure on an annual basis that were published as White Papers with the Budgets. In 1945, his last year at the CSO, he produced figures covering the years 1938-44. This modest start laid a solid foundation for national income accounting in the UK and eventually led to the Blue Books on *National Income and Expenditure* as we know them today. Despite his departure from the CSO, as we shall see below, Richard Stone continued to play a central role in the development of the standardised System of National Accounts that was subsequently adopted by the United Nations.

While at the CSO, Stone usually went to see Keynes in the evening; Keynes was then a sick man, often tired and edgy, so their meetings were not always harmonious and could

end in blow ups with Keynes saying he never wanted to see Dick again. Stone rode out such storms with his usual aplomb and good sense: “ ... rather worrying when it first happened but there was really nothing to worry about”, [167, p.27]. As it turned out, one important offshoot of their association was the appointment of Richard Stone as the first Director of the newly created Department of Applied Economics (DAE) at Cambridge in 1945.

Through Keynes’s influence the Faculty of Economics and Politics had considered such a development in the immediate pre-war years but it was not until after the war ended that the project was implemented. In 1944 the Faculty Board appointed a Committee of Management. Keynes was Chairman, the members were David Champernowne, Austin and Joan Robinson, Gerald Shove, Piero Sraffa and Dennis Robertson (co-opted). In November 1944 a “surprised and delighted” Dick was offered the post, on 15 May 1945 the University gave its blessing and Dick was appointed Director from 1 July 1945.<sup>4</sup>

As Director, Stone was given a free hand in initiating the Department’s main programme of research. Encouraged by this he developed a research proposal organised around the aims of econometrics, which to him were defined much more broadly than its narrow text book sense of today. He certainly believed that input-output analysis, for example, was an integral part of econometrics. (Pesaran 1991, 108). He submitted his research proposal to the Nuffield Foundation in the summer of 1945. The proposal spelt out in some detail his views regarding the aims of the new Department, which were to provide a synthesis of measurement, economic theory and statistical methodology. He wrote:

... The ultimate aim of applied economics is to increase human welfare by the investigation and analysis of economic problems of the real world. It is the view of the Department that this can best be achieved by the synthesis of three types of study which now tend to be pursued in isolation. The Department will concentrate simultaneously on the work of observations, i.e. the discovery and preparation of data; the theoretical appraisal of problems, i.e. the framing of hypotheses in a form suitable for quantitative testing; and the development of statistical methods appropriate to the special problems of economic information. The special character of the

---

<sup>4</sup> The reasons given for establishing the DAE are prescient. The need for emphasis on more applied work, already recognised at the end of the 1930s, was reinforced by the huge strides in applied work during the war and its importance for the war effort itself. Gerald Shove (as Secretary of the Faculty Board) was the go-between with Dick as he moved towards acceptance of the post. We have seen the file in which their courteous and incredibly detailed correspondence over specific points is held.

Department's approach to the problems of real world will lie in this attempt at systematic synthesis.

This synthesis lies at the heart of Stone's approach to applied economics, a theme which he returns to in some detail in his Newmarch Lectures *The Role of Measurement in Economics*, [ 32].<sup>5</sup> Stone's emphasis on econometrics as the unifying theme of his research programme is noteworthy, particularly considering that he was fully aware of Keynes's scepticism and the hostility of some of the main figures in Cambridge to econometrics.<sup>6</sup> Stone [167], however, later argues persuasively that by 1945 Keynes had changed his mind about econometrics. (Pesaran 1991, 99).<sup>7</sup>

From the inception of the DAE there were close links with the National Institute of Economic and Social Research (NIESR) of which Dick's second wife, Feodora, was Secretary. (His first marriage was dissolved in 1940 and he married Feodora Leontinoff in 1941.) Several distinguished economists had either successive or joint posts at the Institute – Sig Prais, Christopher Dow, Deborah Paige, for example. The Faculty had originally thought of the DAE as partly a complementary institution in which research projects of the teaching officers of the Faculty would be carried out in co-operation with research officers of the DAE. In fact when Dick was Director, his drive, enthusiasm, inspiration and excellence made the DAE so much more than this limited, if worthy, aim.

Some of the world's greatest economists and econometricians spent part of their youth at the DAE where remarkable work, especially in the post-war development of econometrics, occurred: Durbin and Watson on testing for residual serial correlation, Cochrane and Orcutt on the estimation of regression models with serially correlated errors, Aitchison and Brown on the lognormal distribution, Brumberg on life-cycle

---

<sup>5</sup> In his review of the Newmarch Lectures, Klein (1952, 104) states: "Stone possesses a rare combination of abilities – an intimate knowledge of data collecting, of the use of data in statistical manipulation, of theoretical methods of statistics, and of theoretical economics."

<sup>6</sup> In his piece in memory of Stone, Richard Goodwin writes: "...though Stone had been taught as student by Kahn, the two had grown apart because of Kahn's active hostility to econometrics." Goodwin (1995, 17).

<sup>7</sup> Stone offers three reasons for Keynes's hasty dismissal of Tinbergen's (1939) work: Keynes tended to overstate his case, his mathematics had become pretty rusty by the thirties, and "Keynes's reaction to anything new was to look for the weak spots and shoot them full of holes." (Pesaran 1991, 98). For a discussion of Keynes on Tinbergen see Pesaran and Smith (1985).

models, Houthakker on revealed preference and applied demand analysis, Prais on family budgets, Farrell on dynamic demands and on aggregation theory, Alan Prest and Derek Rowe on demand analysis, A.D. Roy on the distribution of income, Phyllis Deane and Brian Mitchell on British economic history.<sup>8</sup> In addition the Department hosted many distinguished visitors, who made significant contributions of their own and had an important influence on the research activity of the Department. They included T.W. Anderson, Duesenberry, Friedman, Frisch, Geary, Koopmans, Samuelson, Tintner, Tobin, and Wold.<sup>9</sup> Under Stone's leadership the DAE became one of the leading research centres in quantitative economics in the world. (Johansen 1985, 5).

Another important factor in the DAE's success was its "human computer" facilities<sup>10</sup>, and its access to major advances that had been achieved in computer technology during the War, largely as a result of work carried out at Bletchley Park (also known as *Station X*) to decipher the codes from the Germans' Enigma machines. Orcutt was invited to the DAE from the Massachusetts Institute of Technology, where he had been an Instructor in Economics, to bring his expertise in analog computing to Cambridge. Orcutt's electronic "regression analyser" was demonstrated in January 1947 with many distinguished Cambridge figures, such as Daniels, Hartree, Jefferys, Wilkes, and Wishart invited to attend. Edward Shire from the Cavendish Laboratory also had done similar work during the War.<sup>11</sup> Accordingly, Stone wrote to Brigadier J.B. Hickman (Director of Signals and Radar Development) on May 14<sup>th</sup> 1947 for a loan of the computing machine designed and built by Shire. In his letter Stone explains:<sup>12</sup>

---

<sup>8</sup> A detailed account of these and other development of econometric methods at the DAE is given in Smith (1998). See also the first four Reports of the DAE which cover the period of Stone's tenure, 1945-55.

<sup>9</sup> Tobin's contributions were particularly noteworthy and formed the basis of many subsequent developments in empirical demand analysis. A retrospective evaluation of Tobin's (1950) work on the analysis of food consumption in the US is given in Magnus and Morgan (1997).

<sup>10</sup> As Durbin explains, "...one of the assets of the DAE was that we had a room there with perhaps eight or ten young ladies operating desk calculators, supervised by an older lady of forbidding demeanour. They did the computing." Quoted in Smith (1998, 98).

<sup>11</sup> It was also suggested to Stone to contact Alan Turing a Fellow of King's College, then at the National Physical Laboratory and Tommy Flowers at the Post Office; two of the early pioneers in the development and the use of computer technology at Bletchley Park. An account of the involvement of Turing and Flowers at Bletchley Park is given by Michael Smith (1998).

A large part of our work is concerned with the statistical problems involved in the analysis of time series which forms the basis of much of the information available about economic change. We are working both on actual economic series and on constructed examples with a view to finding out more about the mathematical specification of series appropriate to the description of economic variations over time and we should find the machine which Mr. Shire has built of great value in our work. In particular we should like to use it on the following problems:-

- (1) The investigation of the autoregressive nature of a large number of economic time-series.
- (2) The investigation of the time relationships between these economic time-series as reflected in the correlograms between series.
- (3) The investigation of the correlograms of large numbers of constructed series both with themselves lagged and with each other. This is necessary for an interpretation of the correlograms of real series.

The machine was picked up by Stone, Shire and Orcutt on July 28, 1947 from the Ministry of Supply, and probably used by Cochrane and Orcutt in their work on autocorrelation. Later the DAE started to use the Electronic Delay Storage Automatic Calculator (EDSAC) developed at the Cambridge Mathematical Laboratory, again one of the first computing machines of its generation.<sup>13</sup>

Stone himself continued to work simultaneously on national income accounting and demand analysis. In addition to his work at the CSO on the UK economy, Stone had also published a fairly complete set of accounts for the United States in 1942, and together with Meade had produced a little textbook, *National Income and Expenditure*, which was illustrated with estimates from Britain and America, [9,11,13,14,16].<sup>14</sup> Stone was therefore the obvious person from the UK to be involved in the design and the development of an international standard for national income accounting. Initially, in 1944 he was sent by the CSO to discuss the presentation and taxonomy of national income accounting with his American and Canadian counterparts. But the break came in September 1945 during a visit to the Institute for Advanced Study in Princeton when Alexander Loveday, the Head of the Intelligence Department of the League of Nations, invited Stone to write a report on national income statistics. This report turned out to be the most important work of this early period and was published as the Appendix to the

---

<sup>12</sup> Stone's papers kept at King's College Archives.

<sup>13</sup> See Smith (1998, 97-99) for further details of the role of computing in the success of the DAE in its early period.

<sup>14</sup> This became a very popular text which was then subsequently rewritten with Giovanna Stone, [79].

UN publication, [24]; it provided the basic framework for the System of National Accounts (SNA) currently used throughout the world.<sup>15</sup> In this appendix, Stone presented a picture of an economic system in terms of transactions organized in such a way that various national aggregates of interest could be obtained by adding up appropriate entries in the different accounts. He viewed the economy as a system of interlocking transactions, and the accounting as a way of taking a snap picture of these transactions. He developed his concepts more from an abstract perspective rather than the prevailing accounting conventions. His aim was to develop a system of social accounts that was flexible enough to be of relevance to different countries at different stages of their economic development, while at the same time simple enough to take root and become acceptable, and yet have the proper logical structure for use in empirical analysis, [24, pp.112-113]. Stone had set himself, and his collaborators at the UN and at the OEEC (since 1961 the OECD), a formidable undertaking which he managed to accomplish with flying colours.<sup>16</sup> As one of the pioneers of national and social accounting Stone was probably more responsible than any other single person for the SNA. It was for these “fundamental contributions to the development of national accounts” that he was awarded the 1984 Nobel Memorial Prize in Economic Science, [191,192].

Stone’s accounts are usually presented in a matrix format, a social accounting matrix. In this way both the Keynesian expenditure, production and income flows, and the classical ‘production of commodities by means of commodities’ may be made explicit, together with their interrelationships with each other. As Deaton (1987, 510) noted perceptively, “it is almost impossible to look at them for long without being led into attempts to model the behaviour they reveal”. While Dick was always glad to be associated with the international developments of the national accounts of later years and made indispensable contributions to them, he much preferred the early years when a few kindred souls could meet together in New York and, by working hard for a few weeks (mostly nights), get the

---

<sup>15</sup> See United Nations (1953, 1968).

<sup>16</sup> Stone directed the OEEC’s National Account Research Unit in Cambridge over the years 1949-1951. He chaired the meeting of the UN Statistical Commission in New York in July 1952, which led to the first SNA, published in 1953 and referred to above. For further details see Johansen (1985, 6-13), Pesaran (1991, 94-95), and the chapters by Hill and Raa in Giovannini (1995).

final product out so near to its initial draft that the essential unity of the best sort of first drafts (which these were) was not lost – as they may be in the interminable committee and redrafting processes that occur now, see Pesaran (1991, 94-95), Harcourt (1995, 157), for Dick’s account of these episodes and developments.

When developing the national income accounts in 1941, Meade and Stone were also concerned about the statistical discrepancies (or residual errors) which inevitably arise when attempts are made to reconcile direct measurements of different items in the national accounts. In the following year Stone, Meade and Champernowne, [10], proposed a procedure for balancing the entries in the national accounts by an optimal distribution of the errors across the accounts based on least squares. Subsequently, Byron (1978) reformulated the problem in terms of a constrained quadratic optimization problem and was able to apply the new solution method to fairly large data sets.<sup>17</sup> The adjusted accounts balance by construction, and arguably are an improvement over the initial unadjusted estimates. Despite its obvious advantages, the Stone-Meade-Champernowne adjustment technique has not been widely adopted. Official application of and experimentation with the technique seems to have been confined to the UK and Italy. (Pesaran 1991, 110).<sup>18</sup>

The original motivation behind Stone’s work on consumer demand was also national income accounting. The work on this project had begun at the NIESR in 1941. Initially, the aim was to compile and process the statistical information needed to prepare national income and expenditure accounts for the inter-war years; thus extending backwards the work of the first national income White Paper that had just been published in that year.<sup>19</sup> But inspired by the work of Henry Schultz (1938) on demand analysis, Stone decided to extend the project’s remit to include a detailed econometric investigation of consumption behaviour in the UK. This proved to be a formidable undertaking. It involved a huge

---

<sup>17</sup> The adjustment techniques are further refined by van der Ploeg (1982), Barker, van der Ploeg and Weale (1984), and more recently by Weale (1992) and Smith, Weale and Satchell (1998).

<sup>18</sup> The influence of Stone’s work on recent developments in Italian national accounts is discussed in Pedullà (1995).

<sup>19</sup> See “The Analysis of the Sources of War Finance and an Estimate of the National Income and Expenditure in

amount of data compilation and processing, both from household budget surveys and time series, and required considerable theoretical work on the formulation of suitable econometric specifications and the development and adaptation of time series and cross section econometric techniques for demand analysis. Stone's first major contribution in this area was the *Analysis of Market Demand* which he read to the Royal Statistical Society in April 1945, [17]. The paper proved a great success and, "in its sphere" was said to be "the best ever read before [the] Society", [17, p.384]. It addressed many issues of concern in economic and statistical theory; and provided a first comprehensive application of Frisch's (1934) confluence analysis to time series data. The empirical analysis and the ensuing discussion also raised further issues of concern: the problem of dynamics and residual serial correlation, the simultaneity problem, structural change and the fragility of confluence (bunch map) technique to the joint presence of the residual serial correlation and the simultaneity problems, highlighted by Champernowne, [17, pp.385-387].

Stone continued his work on demand analysis, presiding over and contributing greatly to the pioneering studies which were subsequently published in two volumes, known as the "Red Books", [56,123]. The first volume, published in 1954, was a *magnum opus*, a veritable *tour de force*.<sup>20</sup> Deaton, who more than anyone else was to carry on from where Stone started, singles out for praise the explicit description of data, the "masterly exposition of the theory of demand and of revealed preference and [the] chapter on econometric methodology which reads like a text until one realises that this is where the texts originated" (Deaton 1987, 510). For each commodity there is log-linear formulation with the logarithm of quantity related to the logarithm of income and other prices, and to other factors specific to each commodity. With a lack of degrees of freedom because there were only 19 annual observations, theory and prior information had to be used ingeniously – and Dick was a master of ingenuity and innovation in these dimensions. Deaton (1987, 511) lists four examples:

First, the Slutsky decomposition [is used] to absorb the income effects of prices into the

---

1938 and 1940", Cmd. 6261, 1941. Also see [8].

<sup>20</sup> In producing the first volume Stone was assisted by D.A. Rowe, W.J. Corlett, Renee Hurstfield and Muriel Potter. The second of the Red Books was co-authored with D.A. Rowe.

income term ... converting the latter into real rather than money income. Second,... zero degree homogeneity [is used] to convert prices to relative prices, saving one degree of freedom. Third, he [used] elasticities estimated from Engel curve analysis on cross-sectional household budget data to estimate the income elasticities so that, with these imposed, the time-series data are liberated to estimate as many price effects as precisely as possible. Fourth, Stone [recognized] the difficulties presented by strong positive autocorrelation in the residuals and to counteract them [took] first differences of model and data prior to estimation. The problems that non-stationary time-series pose ... is very much a current research topic, and Stone's procedure, though less than perfect, is much superior to and much less misleading than the ignoring of the problem that characterized most applied work for the quarter of a century after Stone's book. His general procedure set up, Stone ...[analyzed] commodities one by one, [reported] results and [tested] alternative specifications with a care and conviction that has been a model for generations of those ... who have tried to follow him.

The first Red Book was also remarkable in establishing much of the familiar text-book single-equation regression framework, [56, Chapter XIX].<sup>21</sup> It provided a comprehensive and formal discussion of the various econometric issues involved in demand analysis; in part responding to some of the comments and suggestions made on his earlier publication, [17].<sup>22</sup> The problems of dynamics and simultaneity were addressed in some detail, regression in first-differences was emphasized as a relatively simple method of dealing with the problem of "spurious correlation", the errors-in-variables problem and its solution by the instrumental variables method suggested by Reiersol and Geary was discussed, multicollinearity, the use of extraneous estimators (such as estimates of income elasticity derived from budget surveys) and specification of trends were addressed.<sup>23</sup> Stone continued to use Frisch's bunch-map analysis, but now treated it as one of a number of possible techniques available for dealing with the errors-in-variables problem.<sup>24</sup> He abandoned the confluence analysis later. (Pesaran 1991, 103).

The empirical analysis in the Red Books allowed for the possible effects of the prices of

---

<sup>21</sup> According to Stone [56, xxii], the form of this chapter owes much to Durbin and Watson, who had already used similar matrix notations in their own classic papers, Durbin and Watson (1950, 1951).

<sup>22</sup> In his review of the first Red Book, Cochrane (1954, 286) states: "Particularly interesting at this stage in the development of econometrics are Mr. Stone's two thoughtful chapters on the place and objects of econometrics (Introduction and Chapter XVII). They should be read by all economists."

<sup>23</sup> Though he fully agreed in principle with Haavelmo's (1944) simultaneous equation system approach, he thought that "with the many other difficulties in time series regression analysis" he would leave it for another time - in this case, for ever, he was "sorry to say". (Pesaran 1991, 103).

<sup>24</sup> By the time Stone got round to publishing the first Red Book the bunch map technique has come under serious criticisms. For example, Klein (1952, 105) commented that he "...finds it difficult to accept Stone's reliance on

competing and complementary commodities on consumer demand, but did not treat the demand functions for different goods as a complete and a coherent system. Stone was fully aware of this, but for practical reasons in this early work confined his investigations to a single equation approach where demand for each commodity or group of commodities was analysed separately. This was rectified in his seminal 1954 *Economic Journal* paper on linear expenditure systems (LES), [53]. This represented a complete demand system which allowed demand for each commodity to be influenced by all prices without introducing an excessive number of parameters into the model. The theoretical model had already been developed by Klein and Rubin. The innovation was a direct confrontation of theory with empirical evidence, considered by Deaton to be “the real originality and importance of the paper”. No one beforehand had “had the extraordinary idea that it might be possible to use economic theory to confront the data so directly ... to estimate the parameters of a *utility* function [as opposed to demand equations] ... Stone’s linear expenditure system is a major landmark along the route that leads to where we are now” (Deaton 1987, 511, emphasis in original). The linear expenditure system was extended by Stone and his collaborators in a number of directions. Stone and Croft-Murray consider a dynamic version of the model, where short-term and long-term elasticities of demand could be distinguished, [67]. LES with time varying parameters were estimated in [105,108]. It was clear to Stone that with rising living standards, the assumption of fixed parameters underlying the basic model was not plausible. He considered simple time-varying specifications with linear and quadratic trends. But rejected them both in favour of a habit persistent model in which the parameters were allowed to vary with a vector of lagged three-year moving averages of the consumption expenditures, [105]. This time-varying specification would in effect introduce lagged consumption expenditures into the utility function, which has recently become popular in the life-cycle literature. See, for example, Muellbauer (1988).

Stone’s other major empirical contribution during his tenure as the Director was the application of the method of factor analysis to US macroeconomic time series. The method, also known as principal components, was developed and applied in psychology,

---

confluence analysis....”

but Stone was the first to recognize its potential importance for the analysis of time series data. In the late 1940s the only macroeconomic time series data available were annual data between the two wars (17 annual observations), and all the macro series were dominated by the boom in the 1920s and the great depression that followed. Using the principal component analysis developed by Hotelling (1933), Stone was able to formally demonstrate that three factors (namely total income, its rate of change and a time trend) explained over 97 per cent of the total variations of all the 17 macro variables that he had considered. Although there were serious issues of interpretation, the results made an important impression on young applied econometricians such as Tobin who at the time were working on aggregate time series data.<sup>25</sup> The realization that it was possible to explain a significant degree of total variance of almost *any* aggregate variable by means of three factors only, was rather disconcerting and led many researchers to consider cross-sectional data as an alternative source for empirical analysis. This also raised the further issue of how best to combine or pool estimates from cross-section and time-series analyses.

1945-55 was a remarkable 10 year period and established the DAE as an international centre for econometric research on a par with the Cowles Commission. See, for example, Epstein (1987) and Pesaran (1987). Deaton (1987, 512) says of the joint output of those years that it represented “an explosion of econometric and economic knowledge that has never been exceeded in the history of the subject ... perhaps only been equalled by the work of the Cowles Commission”. It was a happy period for Dick who was the most excellent leader of a team imaginable.

These days the Director of the DAE is also appointed to a Chair of Applied Economics which he or she may hold when they cease to be Director. But in Dick’s day, the Directorship was the equivalent of a University Lecturer. So when Stone was offered the P.D. Leake Chair of Finance and Accounting, it was literally an offer he could not refuse even though it meant giving up the Directorship. He continued to head up a sizeable research group – the DAE growth project with Alan Brown – but it was a sad occasion for

---

<sup>25</sup> See Tobin (1997, 648-49).

him. His relationship with the new Director, Brian Reddaway, was always mutually cordial and cooperative but there was an undercurrent of feeling that Dick had been pushed as well as pulled by elements in the Faculty who felt that the more limited original aim of the DAE had not been stressed enough by Dick as Director and who also felt that Dick's work on demand analysis was not what should have been emphasised, or even done.<sup>26</sup> This largely reflected the hostility of prominent Cambridge figures such as Kahn and Joan Robinson to econometrics.<sup>27</sup> It is indeed a sad comment on how econometrics was received in Cambridge and, in particular, on a lack of appreciation of Dick's significant contributions to the subject. It is perhaps ironic that in the year in which Stone was eased out of the Directorship of the DAE he was President of the Econometric Society.<sup>28</sup>

Giving up the Directorship of the Department had very little effect on his research, and if anything it freed him from administrative duties. (Pesaran, 1991,105). He continued his work on consumption behaviour, national income and social accounting, and at the same time together with Alan Brown started the Cambridge Growth Project. In the area of consumption analysis he concluded his work on consumers' expenditure and produced the second Red Book. But due to his new interest in national macroeconomic modelling he did not get round to incorporating the systems approach that he had pioneered earlier, [56]. This second volume, co-authored with D.A. Rowe [123], provided expenditure figures for more commodity groups and a longer time period: 1900 to 1955. It did not contain new analysis, but proved a very useful collection for empirical demand analysts.<sup>29</sup>

Stone had moved away from the standard log-linear specification that he had estimated in the first Red Book, and did not see much point in further application of the single-equation methodology to the new data set. His preferred methodology was now to analyse dynamic demand equations within a simultaneous system where cross-elasticities *and*

---

<sup>26</sup>It is interesting to contrast this view with those of Klein (1952) and Harberger (1955) who in their reviews of Stone's work on demand analysis hailed it as "classics of econometrics". See also Smith (1998, pp.88-89).

<sup>27</sup> See Smith (1998) who also provides a detailed account of the development of econometric methods at the DAE.

<sup>28</sup> In the file mentioned in footnote 4 above, there is part of a letter in which Stone muses about his failure to insist, at the time of his appointment, that the Director ought also to hold a chair, at least in the fullness of time!

<sup>29</sup> Lester Taylor (1969) reviewing the book in *Econometrica*, concluded that "It is hard to imagine a more useful

adjustment rates could be estimated jointly and in a consistent manner, [123, xi]. This required a great deal more work and became one of his main pre-occupations, until he passed on the task to Angus Deaton in early 1970's.

Largely in collaboration with Rowe he produced a series of papers on modelling of the consumption of the durable goods and aggregate private savings. Durable goods consumption was modelled by distinguishing between stocks and flows and assuming that total durable consumption is met from stocks and to a lesser extent from current purchases. The ratio of stocks to expenditure on durables was assumed to be constant in equilibrium, with actual stocks adjusting to the equilibrium values via a partial adjustment mechanism, [63,65,72]. This produced what is now readily recognized as a first order error correction specification in the three variables: real expenditure on durables, total real expenditures and their relative prices. The model produced reasonable estimates, except for the durability parameter reported in [72] which were thought to be too low. This was perhaps one of the first examples of the error correction model estimated in the literature.<sup>30</sup> In their analysis of aggregate private savings Stone and Rowe distinguished between permanent and transitory components of income, consumption and wealth and modelled the permanent component of consumption in terms of a linear function of the permanent components of income and wealth, [89,104,122,145].<sup>31</sup> They then derived an autoregressive distributed lag model in terms of the observables, namely aggregate consumption, real disposable income, and wealth measured at the start of the period. For estimation purposes Stone preferred to work with a saving rate specification, rather than a log-linear one. In fact, it turns out that in practice both formulations yield very similar results, although the saving rate specification is more readily reconciled with an underlying optimization model. Stone and Rowe managed to produce very sensible results, even though they were not aware of the distributional implications of unit root processes. This is perhaps not surprising since, as shown by Pesaran and Shin (1999),

-----  
collection.”

<sup>30</sup> Another notable example of the error correction specification was given a few years later by Sargan (1964) in his famous study of wages and prices in the United Kingdom.

<sup>31</sup> Stone's interest in modelling of aggregate consumption expenditure dated back to a paper on “The Marginal Propensity to Consume and the Multiplier,” which he published with his first wife, W.M. Stone, in 1938, [3].

the estimation of ARDL models that underlie the regressions estimated by Stone and Rowe can be carried out using standard techniques, irrespective of whether the regressors are first-difference or trend-stationary.<sup>32</sup>

When Alan Brown and Dick started the Cambridge Growth Project, they had in mind a model which allowed both 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. A similar attempt had been made in Norway by Lief Johansen (1960). The project became team work in the best sense of the term. Several economists cut their eye teeth in research under the benevolent and helpful gaze of Dick and Alan: among them were Angus Deaton, Graham Pyatt, Jack Revell, Terry Barker, William Peterson, Rick van der Ploeg and Martin Weale. The model was eventually to take in all aspects, real and financial, of the economy – the latter, not without difficulties.

In constructing the Cambridge Growth Project model extensive use was made of Social Accounting Matrices (SAM), which also formed the main building blocks of the applied or computable general equilibrium models which were later developed at the World Bank and elsewhere. In this sense the Growth Project model can be viewed as an immediate precursor of the computable general equilibrium models.<sup>33</sup> The first study to come out of the project was entitled *A Computable Model of Economic Growth*, [85], and described the model, the purposes behind its construction, and its uses. Never small, the model ended up very large, with 5686 variables, 507 of which were exogenous, leaving 5179 equations, and changing “a great deal in 30 years”. The model was not intended for forecasting as such but to see, for example, what the economy would look like in, say,

---

<sup>32</sup> However, the problem of testing the existence of a long-run relationship between the variables under consideration (or equivalently testing the hypothesis that the error correction coefficient is zero, the parameter  $r$  in [72]) *will be* non-standard, irrespective of whether the regressors are first-difference or trend-stationary. See Pesaran, Shin and Smith (1999).

<sup>33</sup> A similar point is made by Graham Pyatt (1992, 245) who was both with the Growth Project as well as being involved in the early development of the computable general equilibrium (CGE) models. See Pyatt and Round (1985). For surveys of CGE models see Shoven and Whalley (1984, 1992).

1970 if it had grown at a little over 4 per cent per annum in the 1960s, compared to 3 per cent per annum in the 1950s. Between 1962 and 1974 twelve books were published in the Green Book series, *A Programme for Growth*. Dick himself subsequently thought of making a precise, manageable model of the larger version, in which it would be possible to see reasonably well what was going on, the sort of exercise that can be done only after years of absorption in the processes of constructing a huge model; but he never did find time to do so before his death in 1991. After Dick retired in 1980, Terry Barker developed, very much with Dick's blessing, a dynamic version of the model which is still going strong. See Barker and Peterson (1987) and Barker (1998, 18-20).

A long standing interest of his middle to late years were the social aspects of demographic growth and education. This work was prompted by Stone's desire to incorporate education, training and manpower into the Growth Project; an objective that he was not able to achieve. (Pesaran 1991, 109). But he constructed a series of social and demographic accounts where he displayed the flows of individuals in a "demographic matrix" with the human being as the unit of account. In the case of education, for example, the demographic matrix would show the number of individuals in different states (infancy, learning, education, employment, unemployment, retirement, and death) at the beginning and the end of a given period. The demographic matrix was then linked to the "economic matrix" which measures the transactions relating to incomes and expenditures of different groups. The linkages between the two accounts was achieved by appropriate consolidation of all non-production accounts so that the economic matrix was reduced to a set of accounts partitioned into education and other activities, [176]. In this way the concept of labour, for example, in the economic accounts could be directly related to the entries in the demographic accounts. Another example is the link between socio-economic characteristic of population and the resources needed to meet their needs for health services. The applications of an integrated economic-demographic set of accounts are innumerable. In his own work Stone focussed on modelling of education, [111,116,142]. He wrote extensively on different aspects of demographic and social accounting since the late 1960s, [115,127,128]. In 1971 the OECD published his *Demographic Accounting and Model Building*, [134]. Subsequently, the UN approached

him to prepare a similar report for their Statistical Office. (Pesaran 1991, 109). After the usual meetings and consultations the final report, *Towards a System of Social and Demographic Statistics* (SSDS), was eventually published in 1975.<sup>34</sup> Though his contributions here were not to make as great an impact as his other contributions, they were characteristically deep and thorough, reflecting his explicit desire always to marry useful theory with sound empirical work, the better to understand and advise, to provide a scientific back-up to the task of improving the lot of ordinary men and women.<sup>35</sup> This had been his ultimate goal from the time when, as a young idealist, he had had that first serious clash with his more conventional father concerning his desire to change from law to economics. (Fittingly, the reading at his funeral service in King's was from Revelations 21: St John describes the coming of the New Jerusalem.)

Feodora Stone died in 1956. In 1960 Dick married Giovanna Croft-Murray (née Saffi) with whom he had collaborated on a book, Stone and Croft-Murray [67], which was part of the origin of the Growth Project. Giovanna was to be “the partner in all his work” (Deaton 1993, 10) from then on. It was a most happy partnership; after Dick died in 1991, Giovanna edited his 1986 Raffaele Mattioli Lectures on *Some British Empiricists in the Social Sciences 1650 - 1900* for publication by Cambridge University Press in 1997. Angus Deaton (1993, 12) has described the cooperative production of the growth project Green Books at the Stone's elegant house *cum* study *cum* library, 13 Millington Road.

The main room at Millington Road is long and narrow, with black walls. It looks out over a rose garden [;] by day, the black walls make it seem shallow, and project the room into the garden. By night there are pools of light, near the fire, by the Bösendorfer, and over the round dining table, which is covered with yellow leather. This was not only the family sitting and dining room, but was also a place of work. Indeed, for Dick, there never could be any separation between his work, his family, and his friends. Not everyone liked to live in such a way, and for those who preferred an eight hour day, the late night editing sessions for the Green Books were less than fully appreciated, however lively the atmosphere and good the wine. But for many more

---

<sup>34</sup> An earlier draft was published under Stone's name in *Sankhya* [136].

<sup>35</sup> Stone himself notes that to his knowledge only the Central Bureau of Statistics of the Netherlands seem to have taken up his ideas on demographic accounting. (Pesaran 1991, 109). But his ideas on social and demographic accounting did attract considerable interest among the academics, particularly in the US. [143,176].

of us, Millington Road became a very special place. Dick and Giovanna kept a splendid dinner table. The round table could accommodate almost any number, and the more people the more were the opportunities for displaying the multicolored collection of glassware. Anyone interesting who came through Cambridge would be invited

... There was a constant stream of pilgrims from all over the world, from distinguished Nobel laureates to research students with barely a word of English. Giovanna always guided the conversation with her characteristic wit, grace, and (when necessary) outrageously provocative statements. Dick would preside, enjoying the food, the wine, the talk, his guests, and the sense of presiding over a worldwide community of scholars and friends. ... the model of affability, he would agree to the most preposterous statements. 'I suppose, when you come to think of it, you're right,' and just for a moment, you would be struck with the wisdom of your remark. Just ... *very* occasionally, and only when pressed, would come the counterpart, 'Well, if you ask *me*, it's all the most frightful rot!' (emphasis in original)

Besides his technical writings, Stone wrote many papers of general and historical interest.<sup>36</sup> He gave a lucid account of Game Theory in a review article published in 1948, a topic which he revisited in 1990 on the occasion of the centenary of the Royal Economic Society, [33,205]. He wrote on Keynes, [167], Malthus, [190], Jacob Marschak, [169], Harry Johnson [162], Michael Farrell, [157], Abraham Aidenoff, [158], and Hicks [205]. In his Presidential address to the Royal Economic Society, [179], he presented an overview of the development of economics over the past hundred years and concluded on the following optimistic note:

The vast amount of research in economic theory, econometrics and statistical methods and in all branches of applied economics has borne fruit; the younger generations of economists are technically streets ahead of mine, the gap between the *a priori* and the empirical seems to me to have narrowed considerably, and the tools on offer to the policy-maker are getting more and more sophisticated. [179, p.732]

In his essay on the use of mathematics in the social sciences published in the *Scientific American*, he presents us with a lucid expression of his basic philosophy on how to 'do' economics and indeed, social sciences in general. He wrote:

Except in a few obstinate pockets of resistance, the use of mathematics in the social sciences is now generally accepted. The reason is not to be found in the outcome of any high-flown philosophical battle but in a number of simple facts. In the first place, many branches of the social sciences are obviously, one might almost say aggressively, quantitative. ... In the second place, while theories about the complex systems which are the subject matter of the social

---

<sup>36</sup> Some of Stone's contributions are published in two volumes of his collected essays, [118,137].

sciences can be expressed verbally, their analysis and comparison are greatly helped by formulating them mathematically. In the third place, the application of such theories must remain very general unless the terms in their relationships can be quantified. In the fourth place, mathematics provides a means of obtaining insight even into subjects whose concepts are rather vague and where precise information is hard to come by. Finally, in the social sciences we are interested not only in a description of what happens and of how the different parts of the social system are related, but also in the rational processes that lie behind effective as opposed to ineffective decisions; to a large extent these processes too can be formulated and analysed mathematically, so that our decisions may eventually come to rest a little more on knowledge and a little less on guesswork than they do at present. [103, p.168]

In his last years he was plagued by ill health. But the devoted support of Giovanna and of his many friends still allowed those years to be happy and fulfilled. The award of the Nobel Memorial Prize to Stone in 1984 brought universal recognition and approval from those who knew Stone and his attainments, and stimulated him to work on many other things that he wanted to do but somehow did not seem to have had time for.<sup>37</sup> He had always been interested in historical topics, particularly the history of political arithmetic in social sciences. The invitation from the Banca Commerciale Italiana in Milan to give the Raffaele Mattioli Lectures presented Stone with a new and exciting project. In the lectures he began “with the political arithmeticians of the seventeenth century, Petty, Davenant and King, who ... laid the foundations of the subject”. He followed them with “Fleetwood’s index numbers, Young’s production accounts and Colquhoun’s balances of income and output”. The two remaining rubrics were demography and social studies. Under these he discussed John Gaunt, “the founder of quantitative demography; Halley and the first life table; Farr and vital statistics; Eden and the study of poverty; Florence Nightingale and the reform of the hospital service, and Charles Booth and his monumental survey of the London poor.” For Dick “they are all twelve outstanding examples of the English amateur tradition [for] none of them had any formal training in the fields to which they contributed so much”, [198, xxi – xxii].<sup>38</sup> They were his favourite people in history; he admired them not least because, in their disparate ways, the issues on which they worked and the approaches which they took foreshadowed his own. And, as Luigi Pasinetti (1992,118) perceptively predicted in his affectionate

---

<sup>37</sup> The importance of Stone’s contributions had already been honoured in the UK by a CBE in 1946 and a knighthood in 1978.

<sup>38</sup> The page numbers refer to the version published posthumously. See Stone (1997).

obituary of Dick, “the world community of economists, econometricians and social scientists will [surely] be extremely grateful to [Giovanna Stone]” for ensuring that “these beautiful *vignettes*” are now in the public domain.

As we have already noted, friendship was a most important part of Dick’s life. In the words of one of his long-lasting friends:

...he was reserved but generous of spirit and simple and straightforward of manner. He enjoyed social intercourse and had a warm approach to friends so that it was a great pleasure to be with him and to talk, equally with him and his delightful and vivacious wife. (Goodwin, 1995, 20).

His two most painful years in Cambridge occurred when he was Chairman of the Faculty Board of Economics and Politics for 1970-72, a most stressful faction-ridden period. His two years as President of the Royal Economic Society (1978-80) by contrast were happy and rewarding.

There are legions of stories about Dick. We suppose that the best must be either the Italian shipping story or the account of Dick coming into the room he shared with James Meade in 1940-41, removing the dust from his homburg (the dust had been acquired when Dick got too close to a bomb explosion during an air raid on London) and saying “Really, James, they have gone too far this time”, or words to that effect. See Deaton (1993, 13).

In the *Econometric Theory* interview, Dick set out his wishes concerning the future development of economics. He wished that it would become more empirical, readier to accept the relevance of other disciplines in the social sciences, and “that politicians and administrators [would] learn to make better use of economics, particularly econometrics. But here I may be entering Utopia, so I had better stop”. Of any economist’s potential, he thought we “could push a subject on but not reasonably expect to have the last word.” (Pesaran 1991, 111-112). While Dick rarely challenged the conceptual basis of received theory, he was a master at providing innovative developments within it and in devising ingenious means for testing it effectively.

Dick died on 6 December, 1991 aged 78. He is survived by his wife and his daughter Caroline.

M. Hashem Pesaran and G.C. Harcourt  
Cambridge University

March 1999

## REFERENCES

- Barker, T.S., 1998, 'Large-scale energy-environment-economy modelling of the European Union', in I. Begg and S.G.B. Henry (eds) *Applied Economics and Public Policy*, Cambridge: Cambridge University Press, 15-40.
- Barker, T.S. and Peterson, A.W.A. (eds), 1987. *The Cambridge Multisectoral Dynamic Model of the British Economy*, Cambridge: Cambridge University Press
- Barker, T.S., F. van der Ploeg and Weale, M., 1984, 'A balanced system of national accounts for the United Kingdom' *The Review of Income and Wealth*, 30 (4), 461-485.
- Byron, R., (1978), 'The estimation of large social account matrices', *Journal of the Royal Statistical Society, Series A*, 141, 359-367.
- Cochrane, D., 1954. 'Review of R. Stone, *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920-38. Vol. I*', *The Economic Record*, November, 286-288.
- Deaton, A., 1987, 'Stone, John Richard Nicholas', in J. Eatwell, M. Milgate and P. Newman (eds), *The New Palgrave Dictionary of Economics*, Vol. IV, London and New York: Macmillan.
- Deaton, A., 1993, 'Stone, John Richard Nicholas 1913-1991', *Proceedings of the British Academy*, 82, 475-492.
- Department of Applied Economics, 1948, *First Report: Activities in the Years 1946-1948*, Cambridge: University of Cambridge, Department of Applied Economics.
- Department of Applied Economics, 1952, *Second Report: Activities in the Years 1948-1951*, Cambridge: University of Cambridge, Department of Applied Economics.
- Department of Applied Economics, 1954, *Third Report: Activities in the Years 1951-1953*, Cambridge: University of Cambridge, Department of Applied Economics.
- Department of Applied Economics, 1958, *Fourth Report: Activities in the Years 1954-1957*, Cambridge: University of Cambridge, Department of Applied Economics.
- Durbin, J. and Watson, G.S., 1950, 'Testing for serial correlation in least squares regression I', *Biometrika*, 37, 409-428.
- Durbin, J. and Watson, G.S., 1951. Testing for serial correlation in least squares regression II', *Biometrika*, 38, 159-178.
- Epstein, R.J., 1987, *A History of Econometrics*, Amsterdam: North-Holland
- Frisch, R., 1934, *Statistical Confluence Analysis by Means of Complete Regression Systems*, University Institute of Economics, Oslo.
- Giovannini, E., (ed), 1995, *Social Statistics, National Accounts and Economic Analysis: International Conference in Memory of Sir Richard Stone*, Annali Di Statistica, Serie X, Vol. 6, Rome: Istituto Nazionale di Statistica.

Goodwin, R.M., 1995, 'In memory of Sir Richard Stone', in E. Giovannini (ed), *Social Statistics, National Accounts and Economic Analysis: International Conference in Memory of Sir Richard Stone*, Annali Di Statistica, Serie X, Vol. 6, Rome: Istituto Nazionale di Statistica, 17-20.

Haavelmo, T., 1944, 'The probability approach in econometrics', *Econometrica*, 12, Supplement.

Harberger, A., 1955, 'Review of R. Stone, The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920-1938, Vol. I', *Econometrica*, 23, 217-218.

Harcourt, G.C., 1995, 'Political arithmetic in Cambridge: talking to Richard Stone', in *Capitalism, Socialism and Post-Keynesianism. Selected Essays of G.C.Harcourt*, Aldershot, UK, Brookfield, U.S. & Edward Elgar, 153-59.

Hotelling, H., 1933, 'Analysis of a complex statistical variables into principal components', *Journal of Educational Psychology*, 417-441 and 498-520.

Johansen, L., 1960, *A Multi-sectoral Study of Economic Growth*, Amsterdam: North-Holland.

Johansen, L., 1985, 'Richard Stone's Contributions to Economics', *Scandinavian Journal of Economics*, 87, 4-32.

Klein, L., 1952, 'Review of R. Stone, *The Role of Measurement in Economics*', *Econometrica*, 20, 104-105.

Magnus, J.R. and Morgan, M.S., 1997, 'The Experiment in Applied Econometrics', special issue of *Journal of Applied Econometrics* (guest eds), 12. Chichester: Wiley

Muellbauer, J., 1988, 'Habits, rationality and myopia in the life cycle consumption function', *Annales d'Economie et de Statistique*, 9, 47 - 70.

Pasinetti, L.L., 1992, 'Professor Sir Richard Stone (1913-1991), *Caian: The Annual Record of Gonville & Caius College, Cambridge*, 112-118.

Pedullà, M.G.M., 1995, 'Recent developments in Italian national accounts: the influence of Richard Stone', in E. Giovannini (ed), *Social Statistics, National Accounts and Economic Analysis: International Conference in Memory of Sir Richard Stone*, Annali Di Statistica, Serie X, Vol. 6, Rome: Istituto Nazionale di Statistica, 37-48.

Pesaran, M.H., 1987, 'Econometrics', in J. Eatwell, M. Milgate and P. Neman, (eds), *The New Palgrave Dictionary of Economics*, Vol. II, London and New York: Macmillan.

Pesaran, M.H., 1991, 'The ET Interview: Professor Sir Richard Stone', *Econometric Theory*, 7, 85-123.

Pesaran, M.H., and Shin, Y., 1999, 'An autoregressive distributed lag modelling approach to cointegration analysis', in (ed) S. Strom, *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, Cambridge: Cambridge University Press.

- Pesaran, M.H., Shin, Y., and R. Smith, 1999, 'Bounds testing approaches to the analysis of the long-run relationships', unpublished manuscript, Cambridge University.
- Pesaran, M.H., and Smith, R.P., 1985, 'Keynes on econometrics', in T. Lawson and M.H. Pesaran (eds), *Keynes' Economics: Methodological Issues*, Croom Helm, 1985, pp. 134-150.
- Ploeg, F. van der, 1982, 'Reliability and adjustment of sequences of large economic accounting matrices (with discussion)', *Journal of the Royal Statistical Society*, Series A, 145, 169-94.
- Pyatt, G., 1992, 'In memoriam: Sir Richard Stone, KT, CBE, ScD, FBA. 1913-1991', *Review of Economics and Wealth*, Series 38, 245-248.
- Pyatt, G., and Round, J.I. (eds), 1985, *Social Account Matrices: A Basis for Planning*, Washington: World Bank.
- Sargan, J.D., 1964, 'Real wages and prices in the UK', in P.E. Hart, G. Mills and J.K. Whittaker (eds), *Econometric Analysis of National Economic Planning*, New York: Macmillan. Reprinted in D.F. Hendry, and K.F. Wallis (eds), 1984, *Econometrics and Quantitative Economics*, Oxford: Basil Blackwell, 275-314.
- Schultz, H., (1938), *The Theory and Measurement of Demand*, Chicago: University of Chicago Press.
- Shoven, J.B. and Whalley, J., 1984, 'Applied general-equilibrium models of taxation and trade: an introduction and survey', *Journal of Economic Literature*, 22, 1007-1051.
- Shoven, J.B. and Whalley, J., 1992, *Applying General Equilibrium*, Cambridge: Cambridge University Press.
- Smith, M., 1998, *Station X: The Codebreakers of Bletchley Park*, Channel 4 Books, an imprint of Macmillan, London.
- Smith, R.J., Weale, M.R., and Satchell, S.E., 1998, 'Measurement error with accounting constraints: point and interval estimation with latent data with an application to UK gross domestic product', *Review of Economic Studies*, 65, 109-134.
- Smith, R.P., 1998, 'The development of econometric methods at the DAE', in I. Begg and S.G.B. Henry (eds) *Applied Economics and Public Policy*, Cambridge: Cambridge University Press, 88-103.
- Stone, J.R.N., 1997, *Some British Empiricists in the Social Sciences 1650-1900*. Cambridge: Cambridge University Press. (Posthumous - edited by A.M. Cardani and G. Stone).
- Taylor, L., 1969, 'Review of R. Stone and D.A. Rowe, *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920-38, Vol.II*', *Econometrica*, 37, 361-62.
- Tinbergen, J., 1939, *Statistical Testing of Business-Cycle Theories*, 2 volumes, Geneva: League of Nations.
- Tobin, J., 1950, 'A statistical demand function for food in the USA', *Journal of the royal Statistical Society*, Series A, 113, Part II, 113-41.

Tobin, J., (1997), 'Comments by Professor James Tobin', in J.R. Magnus and M.S. Morgan (guest eds) special issue on 'The Experiment in Applied Econometrics' *Journal of Applied Econometrics*, 12, 647-650.

United Nations, 1953, *A System of National Accounts and Supporting Tables*, New York: United Nations.

United Nations, 1968, *A System of National Accounts*, New York: United Nations.

Weale, M.R., 1992, 'Estimation of data measured with error and subject to linear restrictions', *Journal of Applied Econometrics*, 7, 167-174.

## List of Publications of Richard Stone

### 1936

1. A study of costs (with W.A. Tweddle). *Econometrica* 4 (1936): 226-241.

### 1937

2. Trends (with W.M. Stone). Monthly articles in *Industry Illustrated*, June-December 1937.

### 1938

3. The marginal propensity to consume and the multiplier (with W.M. Stone). *The Review of Economic Studies* VI (1938): 1-24.
4. Trends (with W.M. Stone). Monthly articles in *Industry Illustrated*, January-December 1938.

### 1939

5. Indices of industrial output (with W.M. Stone). *The Economic Journal* XLIX 195 (1939): 477-485.
6. Pitfalls in assessing the state of trade (with W.M. Stone). In *British Management Yearbook* (1939), pp. 21-78.
7. Trend (with W.M. Stone). Monthly articles in *Industry Illustrated*, January-May 1939.

### 1941

8. The construction of tables of national income, expenditure, savings and investment (with J.E. Meade). *The Economic Journal* LI (1941): pp. 216-231. Reprinted in *Readings in the Concepts and Measurement of Income*, R.H. Parker and G.C. Harcourt, ed., Cambridge University Press, 1969.

### 1942

9. The national income, output and expenditure of the United States of America, 1929-41. *The Economic Journal* LII (1942): 154-175.
10. The precision of national income estimates (with D.G. Champernowne and J.E. Meade). *The Review of Economic Studies* IX (1942): 111-125.

### 1943

11. National income in the United Kingdom and the United States of America. *The Review of Economic Studies* X (1943): 1-27.
12. The fortune teller, *Economica* X (1943): 24-33.
13. Comment (on U.S. national income statistics by Milton Gilbert). *The Economic Journal* LIII (1943): 82-83.
14. Two studies on income and expenditure in the United States. *The Economic Journal* LIII (1943): 60-75.

## 1944

15. Employment in U.S. manufacturing. *The Economic Journal* LIV (1944): 246-252.
16. *National Income and Expenditure* (with J.E. Meade). Oxford University Press, 1944; second edition, Bowes and Bowes, Cambridge, 1948; third edition, Bowes and Bowes, Cambridge, 1952, fourth edition, Bowes and Bowes, London, 1957. (See also no. 79 below.)

## 1945

17. The analysis of market demand. *Journal of Royal Statistical Society* 108 (1945): 1-98.

## 1946

18. John Maynard Keynes (obituary). *Economisch-Statistische Berichten* (Amsterdam), 17 July 1946.
19. Lord Keynes: the new theory of money. *Nature* 158 (1946): 652.
20. The national income: a statistical account of the British economy. *The Times*, 27 May 1946.
21. National income and expenditure: the local authority sector. *Local Government Finance*, July 1946.
22. Economic models with special reference to Mr. Kaldor's system (with E.F. Jackson). *The Economic Journal* LVI (1946): 556-567.
23. Social accounting in Holland. *Accountancy*, October 1946.

## 1947

24. Definition and measurement of the national income and related totals. Appendix to *Measurement of National Income and Construction of Social Accounts*, UN, Geneva, 1947.
25. Social accounting: I. National income before and since the war; II. Consumption and the course of prices. *The Times*, 29 and 30 August, 1947.
26. On the interdependence of blocks of transactions. *Supplement of the Journal of the Royal Statistical Society* IX (1947): 1-45.
27. Prediction from autoregressive schemes and linear stochastic difference systems. Paper presented at the ISC, Washington, 1947. In *Proceedings of the International Statistical Conferences, 1947*; Eka Press, Calcutta, 1951.
28. The measurement of national income and expenditure: a review of the official estimates of five countries. *The Economic Journal* LVII (1947): 272-298.

## 1948

29. National accounting and national budgeting for economic policy. *Nationalekonomiska Föreningens Förhandlingar, 1947* (Stockholm), pt. 3, (1948): 63-72.
30. Social accounting, aggregation and invariance. *Cahiers du Congrès International de Comptabilité*, 1948. French translation: *Economie Appliquée*, vol. II, no.1, (1949): 26-54.
31. The analysis of market demand: an outline of methods and results. *Review of the International Statistical Institute* 16 (1948): 23-35.
32. *The Role of Measurement in Economics*. The Newmarch Lectures, 1948-49, Cambridge University Press, 1951.
33. The theory of games. *The Economic Journal* LVIII (1948): 185-201.

34. The presentation of the central government accounts (with F. Sewell Bray). *Accounting Research* 1 (1948): 1-12.
35. British output in 1946-47 (with C.F. Carter and W.B. Reddaway). *The Times*, 18 February 1948.
36. National income: shift of purchasing power from rich to poor. *The Times*, 3 June 1948.
37. *The Measurement of Production Movements* (with C.F. Carter and W.B. Reddaway). Cambridge University Press, 1948; reprinted, 1965.
38. A new index of industrial production (with C.F. Carter, W.B. Reddaway and F. Winter). *Bulletin of the London and Cambridge Economic Service* XXVI (1948).
39. *The Distribution of Income and Saving*. W.F.L. 359. The National Savings Committee, London, 1949.

## 1949

40. Function and criteria of a system of social accounting. Paper presented at the IARIW conference. Cambridge, 1949. In *Income and Wealth, Series I*, Bowes and Bowes, Cambridge, 1951
41. The use of sampling methods in national income statistics and social accounting (with J.E.G. Utting and J. Durbin). Paper presented at the ISI conference, Berne, 1949. *Reviews of the International Statistical Institute* 18 (1950): 21-44; reprinted in *Accounting Research* 1 (1950): 333-356.

## 1950

42. The relationship between input-output analysis and national accounting (with J.E.G. Utting). Paper presented at the first International Conference on Input-Output Techniques, Driebergen, 1950. In *Input-Output Relations*, H.E. Stenfort Kroese, Leiden, 1953.

## 1951

43. Simple transaction models, information and computing. Paper presented at a conference on Automatic Control, Cranfield, 1951. *The Review of Economic Studies* XIX (2) (1951-52): 67-84.
44. The demand for food in the United Kingdom before the war. *Metro-economica* III (1951): 8-27.
45. The use and development of national income and expenditure estimates. In *Lessons of the British War Economy*, Cambridge University Press, 1951.
46. Inter-country comparisons of the national accounts and the work of the national accounts research unit of the OEEC (with Kurt Hansen). Paper presented at the IARIW conference, Royaumont, 1951. In *Income and Wealth, Series III*, Bowes and Bowes, Cambridge, 1953.

## 1952

47. Systems of aggregative index numbers and their compatibility (with S.J. Prais). *The Economic Journal* LXII (1952): 565-583.

## 1953

48. Model-building and the social accounts: a survey. Paper presented at the IARIW conference, Castelgandolfo, 1953. In *Income and Wealth, Series IV*, Bowes and Bowes, London, 1955.
49. Recent developments in national income and social accounting (with Milton Gilbert). Paper

presented at the ISI conference, Rome 1953. *Bulletin de l'Institut International de Statistique*, XXXIV (1954): 367-397; reprinted in *Accounting Research* 5 (1954): 1-31.

50. Forecasting from econometric equations: a further note on derationing (with S.J. Prais). *The Economic Journal* LXIII (1953): 189-195.
51. Report on the evaluative committee for *Econometrica* (with P.A. Samuelson and T.C. Koopmans). *Econometrica* 22 (1954): 141-146.

## 1954

52. Input-output and the social accounts. Paper presented at the second International Conference on Input-Output Techniques, Varenna, 1954. In *The Structural Interdependence of the Economy*, Wiley, New York; Giuffrè, Milan, 1955.
53. Linear expenditure system and demand analysis: an application to the pattern of British demand. Paper presented at the second International Conference on Input-Output Techniques, Varenna, 1954. *The Economic Journal* LXIV, 255 (1954): 511-527. Also in *The Structural Interdependence of the Economy*, Wiley, New York; Giuffrè, Milan, 1955.
54. Misery and bliss. Paper presented at the World Population Conference, Rome, 1954. *Proceedings of the World Population Conference*, 1954, vol. V. pp. 779-798, UN, New York, 1955. Also in *Economia Internazionale* VIII (1955): 72-93.
55. The way the money went. *The Times*, 25 and 26 February 1954.
56. *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920-1938*, Vol. I (with D.A. Rowe and others). Cambridge University Press, 1954.

## 1955

57. National income and national accounts: their construction and use in economic policy (in Greek). *Review of Economic and Political Sciences* (Athens) X (1955): 1-33.
58. Transaction models with an example based on the British national accounts (in Spanish). *Boletín del Banco Central de Venezuela* XV (1955): 12-29. English version: *Accounting Research* VI (1955): 202-226.
59. Some estimation problems in demand analysis (with J. Aitchison and Alan Brown). *The Incorporated Statistician* 5 (1955): 165-177.
60. Aggregate consumption and investment functions for the household sector considered in the light of British experience (with D.A. Rowe). Paper presented at the IARIW conference, Hindsgavl, 1955. *Nationaløkonomisk Tidsskrift* (Copenhagen) 94 (1956): 1-32.

## 1956

61. *Quantity and Price Indexes in National Accounts*. OEEC, Paris, 1956.
62. *Social Accounting and Economic Models* (in Turkish). Ajans-Türk Matbaası, Ankara, 1956.
63. The market demand for durable goods (with D.A. Rowe). *Econometrica*, 25 (1957): 423-443. Reprinted in *Consumer Behaviour*, A.S.C. Ehrenberg and F.G. Pyatt (eds.), Penguin Books, Middlesex, 1971.

## 1958

64. Can economists help business? *The Accountant*, 22 March 1958, pp. 337-340.
65. Dynamic demand functions: some econometric results (with D.A. Rowe). *The Economic Journal* LXVIII (1958): 256-270.

## 1959

66. Market forecasting and the family income. *The Times Review of Industry* 13 (new series) (1959): 6 and 9.
67. *Social Accounting and Economic Models* (with Giovanna Croft-Murray). Bowes and Bowes, London, 1959. Japanese translation (with additions): Toyo Keisai Shinposha (New Publishing Co. of the Eastern Economist), 1964. Spanish translation (with no. 79 below): Ediciones Oikos-tau, Barcelona, 1965.

## 1960

68. A comparison of the economic structure of regions based on the concept of distance. *Journal of Regional Science* 2 (1960): 1-20.
69. A dynamic model of demand (in Polish). *Przegląd Statystyczny* (Warsaw) VII (1960: 255-270. English version in 118 below.
70. Social accounts at the regional level: a survey. Paper presented at the OEEC conference on Regional Economic Planning, Bellagio, 1960. In *Regional Economic Planning: Techniques of Analysis*, OEEC, Paris, 1961.
71. Three models of economic growth. Paper presented at the International Congress for Logic, Methodology and Philosophy of Science, Stanford, 1960. In *Logic, Methodology and Philosophy of Science*, Stanford University Press, 1962.
72. The durability of consumers' durable goods (with D.A. Rowe). *Econometrica* 28 (1960): 407-416. Reprinted in *Readings in Economic Statistics and Econometrics*, Arnold Zelner (ed.), Little, Brown and Co., Boston, 1968.
73. An econometric model of growth: the British economy in ten years time. *Discovery* XXII (1961): 216-219.
74. Consumers' wants and expenditures: a survey of British studies since 1945. Paper presented at the CNRS conference, Grenoble, 1961. In *L'évaluation et le rôle des besoins de biens de consommation dans les divers régimes économiques*, Centre National de la Recherche Scientifique, Paris, 1963.
75. How fast can Britain grow? *The Director* 13 (1961): 286-288.
76. *Input-Output and National Accounts*. OEEC, Paris, 1961. Russian translation: Statistica Publishing House, Moscow, 1964.
77. Multiple classifications in social accounting. Paper presented at the ISI conference, Paris, 1961. *Bulletin de l'Institut International de Statistique* XXXIX (1962): 215-233.
78. Population mathematics, demand analysis and investment planning (in Polish), *Przegląd Statystyczny* (Warsaw) VIII (1961): 127-136. English version in 118 below.
79. *National Income and Expenditure* (with Giovanna Stone). Fifth edition, rewritten, 1961; sixth edition, 1962; seventh edition, 1964; eighth edition, 1966, ninth edition, 1972; tenth edition, 1977; all Bowes and Bowes, London. Spanish translation (with no. 67 above): Ediciones Oikos-tau, Barcelona, 1965. Japanese translation, 1969.
80. A long-term growth model for the British economy (with Alan Brown). Paper presented at the IARIW Conference, Tutzing, 1961. In *Europe's Future in Figures*. North Holland Publishing Co., Amsterdam, 1962.

## 1962

81. A demonstration model for economic growth. *The Manchester School of Economic and Social Studies* XXX (1962): 1-14.
82. Some aggregation problems in input-output analysis (in Polish). *Przegląd Statystyczny* (Warsaw) IX (1962): 25-28.
83. Models for seasonal adjustment (in Polish). *Przegląd Statystyczny* (Warsaw) IX (1962): 119-134. English version in 137 below.
84. The housekeeper and the steersman. *L'industria*, no. 4 (1962): 417-426.
85. *A Computable Model of Economic Growth* (with Alan Brown). No. 1 in *A Programme for Growth*, Chapman and Hall, London, 1962. Czech translation: The Economico-Mathematical Laboratory of the Czechoslovakian Academy of Sciences, Prague, 1965.
86. *A Social Accounting Matrix for 1960* (with Alan Brown and others). No. 2 in *A Programme for Growth*, Chapman and Hall, London, 1962.
87. Behavioural and technical change in economic models (with Alan Brown). Paper presented at the IEA conference, Vienna, 1962. In *Problems in Economic Development*, Macmillan, London, 1965.
88. Output and investment for exponential growth in consumption (with Alan Brown). *The Review of Economic Studies* XXIX (1962): 241-245.
89. A post-war expenditure function (with D.A. Rowe). *The Manchester School of Economic and Social Studies* XXX (1962): 187-201.
90. A generalisation of the theorem of Frisch and Waugh (in Polish). *Przegląd Statystyczny* (Warsaw) IX (1962): 401-403. English version in 137 below.

## 1963

91. Computational analogue of economic growth (in Ukrainian). *Automatika* (Kiev) (1963): 39-45.
92. Consistent projections in multi-sector models. Paper presented at the IEA conference, Cambridge, 1963. In *Activity Analysis in the Theory of Growth and Planning*, Macmillan, London 1967.
93. Models of the national economy for planning purposes. *Operational Research Quarterly* 14 (1963): 51-59.
94. Possible worlds. *The Investment Analyst*, no. 6 (1963): 10-14.
95. Social accounting and standardised national accounts (in Spanish). *Informacion Comercial Española* (Madrid), no. 356 (1963): 31-39. English version in 137 below.
96. The *a priori* and the empirical in economics. *L'industria*, no. 4 (1963): 467-486.
97. The analysis of economic systems. Paper presented at the seventh study week of the Pontifical Academy of Sciences, Rome, 1963. In *Pontificiae Academiae Scientiarum Scripta Varia*, no. 28 (2 vols.), 1965. Also in *The Econometric Approach to Development Planning*, North Holland Publishing Co., Amsterdam, 1965.
98. A programme for economic growth (with Alan Brown). *Data Processing* 5 (1963): 70-77.
99. *Economic Growth and Manpower* (with Alan Brown, Graham Pyatt, and Colin Leicester). Report of the BACIE spring conference, 1963. British Association for Commercial and Industrial Education, London, 1963.

## 1964

100. A framework for economic decisions. *Moorgate and Wall Street*, spring 1964, pp. 5-24; reprinted in *Models for Decision*, English Universities Press, London, 1965.
101. British economic balances in 1970: a trial run on Rocket. Paper presented at the sixteenth symposium of the Colston Research Society, Bristol, 1964. In *Econometric Analysis for National Economic Planning*, Butterworths, London, 1964.

102. Computer models of the economy. *New Scientist* 21 (1964: 604-605; reprinted in *The World of 1984*, vol. 2, Penguin Books, 1965.
103. Mathematics in the social sciences. *Scientific American* 211 (1964): 168-182. Reprinted in *Mathematics in the Modern World*, Freeman, San Francisco and London, 1968. Polish translation: *Matematyka w Swiecie Wsopolczesnym*, Polish Scientific Publishers (PWN), Warsaw, 1966.
104. Private saving in Britain, past, present and future. *The Manchester School of Economic and Social Studies* XXXII (1964): 79-112.
105. The changing pattern of consumption. In *Problems of Economic Dynamics and Planning* (essays in honour of Michal Kalecki), Polish Scientific Publishers (PWN), Warsaw, 1964.
106. *The Model in its Environment* (expanded version of no. 97 above). No. 5 in *A Programme for Growth*, Chapman and Hall, London, 1964. Reproduced in part in *Automatica* 4 (1966): 55-71.
107. Transitional planning. In *On Political Economy and Econometrics* (essays in honour of Oskar Lange), Polish Scientific Publishers (PWN), Warsaw, 1964. Italian translation: *L'industria*, no. 3 (1966): 327-346.
108. Demand analysis and projections for Britain: 1900-1970: a study in method (with Alan Brown and D.A. Rowe). In *Europe's Future Consumption*, North Holland Publishing Co., Amsterdam, 1964. Reprinted in shortened form in *Consumer Behaviour*, A.S.C. Ehrenberg and F.G. Pyatt (eds.), Penguin Books, Middlesex, 1971.
109. The methodology of planning models (with Colin Leicester). Paper presented at the NBER conference, Princeton, 1964. In *National Economic Planning*. National Bureau of Economic Research, New York, 1967. Italian translation: *L'industria*, no. 4 (1968): 409-431.
110. Models for demand projections. In *Essays on Econometrics and Planning* (in honour of P.C. Mahalanobis), Pergamon Press, Oxford; Statistical Publishing Society, Calcutta, 1964.

## 1965

111. A model of the educational system. *Minerva* III (1965): 172-186.
112. Modeling economic system (in Russian). *Economics and Mathematical Methods* (Moscow) I, pp. 363-390, and pt. 4, pp. 502-514, 1965.
113. The Cambridge Growth Project. *Cambridge Research*, October 1965, pp. 9-15.
114. The Social accounts from a consumer's point of view. Paper presented at the IARIW conference, Lom, 1965. *The Review of Income and Wealth, Series 12*, no.1 (1966): 1-33.

## 1966

115. Input-output and demographic accounting: a tool for educational planning. *Minerva* IV (1966): 365-380. Russian translation: *Economics and Mathematical Methods* III (1967): 355-369.
116. Mathematical models in educational planning: a view of the conference. Introduction to the proceedings of a meeting held by the OECD, Paris, 1966. In *Mathematical Models in Educational Planning*, OECD, Paris, 1967.
117. Mathematical models of the economy. *Bulletin of the Institute of Mathematics and its Applications* (1966): 77-87.
118. *Mathematics in the Social Sciences and Other Essays* (containing nos. 54, 68, 69, 70, 71, 77, 78, 81, 84, 93, 96, 101, 104, 105, 106, 107 and 111 above). Chapman and Hall, London 1966. Polish translation, *Matematyka w Naukach Spolecznych*, Polish Economic Publishers (PWE), Warsaw, 1970.
119. *National income*. In Chambers' *Encyclopedia*, fourth edition, 1966.
120. Official statistics: a golden treasury or a working tool? Memorandum submitted to the Subcommittee on Economic Affairs. In *Fourth Report from the Estimates Committee*, H.M.S.O.,

London, 1966.

121. Our unstable economy: can planning succeed? Sixth annual lecture of the U.K. Automation Council, December 1966. Reproduced in *Electronics and Power* 13 (1967): 40 *et seq.*, and in *Control* II (1967): 64-66. Italian translation: *L'industria*, no. 3 (1967): 350-361.
122. Spending and saving in relation to income and wealth. *L'industria*, no. 4 (1966): 471-499.
123. *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom 1920-1938*, Vol. II (with D.A. Rowe). Cambridge University Press, 1966.

## 1967

124. Economic and social modeling. Paper presented at a CEIR conference, London, 1967. In *Mathematical Model Building in Economics and Industry*, Griffin, London, 1968.
125. The generation, distribution and use of income. Paper presented at the ISI conference, Sidney, 1967. *Review of the International Statistical Institute* 36 (1968): 148-157.
126. The use of social accounting matrices in building planning models. Paper presented at the IARIW conference, Maynooth, 1967. In 137 below.
127. An example of demographic accounting: the school ages (with Giovanna Stone and Jane Gunton). Paper presented at the IARIW conference, Maynooth, 1967. *Minerva* VI (1968): 185-212.

## 1968

128. Demographic input-output: an extension of social accounting. Paper presented at the fourth International Conference on Input-Output Techniques, Geneva, 1968. In *Contributions to Input-Output Analysis*, vol. 1, North-Holland, Amsterdam, 1970.
129. A comparison of the SNA and the MPS. Paper presented at the Symposium on National Accounts and Balances, Warsaw, 1968. Polish translation in *Bilanse Gospodarki Narodowej*, Warsaw, 1968. English version in 137 below.
130. The revision of the SNA: an outline of the new structure. Paper presented at the Symposium on National Accounts and Balances, Warsaw, 1968. Polish translation in *Bilanse Gospodarki Narodowej*, Warsaw, 1968. English version in 137 below.
131. Input-output projections: consistent prices and quantity structures. *L'industria*, no. 2 (1968): 212-224.
132. Control of an economic system. In *Encyclopaedia of Linguistics, Information and Control*, Pergamon Press, 1969.

## 1969

133. Foreign trade and full employment: an input-output analysis. *L'industria*, no. 4 (1969): 431-443.
134. *Demographic Accounting and Model Building*. OECD, Paris, 1971.
135. Economic and demographic accounts and the distribution of income. Paper presented at the Symposium on National Economic Modelling, Novosibirsk, 1970. Russian translation: *Economics and Mathematical Methods* VII (1971): 658-666. English version: *Acta Oeconomica* 11 (1973): 165-176.

## 1970

136. An integrated system of demographic, manpower and social statistics and its links with the system of national economic accounts. Report discussed by an expert group convened by the

- Statistical Office of the UN, Geneva, 1970. *Sankhya, Series B* 33 (1971): 1-184.
137. *Mathematical Models of the Economy and Other Essays* (containing 74, 83, 90, 92, 95, 110, 114, 115, 116, 117, 121, 122, 125, 126, 127, 129, 130, 131 and 133 above). Chapman and Hall, London, 1970.
138. Process, capacity and control in an input-output system. *L'industria*, no. 1&2 (1973): 3-17.
139. The fundamental matrix of the active sequence. Paper presented at the Fifth International Conference on Input-Output Techniques, Geneva, 1971. In *Input-Output Techniques*, North-Holland, Amsterdam, 1972. French translation: *Cahiers du Séminaire d'Econométrie*, no. 14 (1972): 9-23.

## 1971

140. A system of social matrices, Paper presented at the IARIW Conference, Ronneby, 1971. *The Review of Income and Wealth*, series 19, no.2, 1973, pp. 143-166. Spanish translation: *Desarrollo Económico* (Buenos Aires) 13 (1973): 169-197.
141. The evaluation of pollution: balancing gains and losses. *Minerva X* (1972): 412-425.
142. A Markovian education models and other examples linking social behaviour to the economy. *Journal of the Royal Statistical Society, Series A (General)* 135 (1972): 511-543.
143. Transition and admission models in social demography. Paper presented at a Conference on Quantitative Social Theory and the Study of Formal Organisations, Virginia, 1972. *Social Science Research* 2 (1973): 185-230; also in *Social Indicator Models*, Russell Sage Foundation, New York, 1975.
144. Demographic growth and the cost of education. In *Population and Growth and Economic Development in the Third World*, 2 vols. International Union for the Scientific Study of Population, Ordina Editions, 1976.

## 1973

145. Personal spending and saving in postwar Britain. In *Economic Structure and Development* (essays in honour of Jan Tinbergen), North-Holland, Amsterdam, 1973.
146. Statistics (in Italian). In *Enciclopedia del Novecento*, vol. VII, Istituto della Enciclopedia Italiana, 1984.
147. Demographic variables in the economics of education. Paper presented at an International Economic Association Conference held at Valescure, 1973, and published in *Economic Factors in Population Growth*, Macmillan, London, 1976. Hungarian translation of a preliminary version: *Demográfia XVII* (1974): 11-41.

## 1974

148. Random walks through the social sciences. Paper presented at the Sixth International Conference on Input-Output Techniques, Vienna, 1974.
149. What is wrong with the national accounts? Paper prepared for the Statistical Office of the United Nations for submission to the Statistical Commission.
150. Towards a model of inflation, 1: a survey of some recent findings on the determinants of changes in wages and prices. Unpublished manuscript.
151. Social statistics and social policy. Paper presented at the 40th Session of the International Statistical Institute, Warsaw, 1975. *Bulletin de l'Institut International de Statistique XLVI* (1975): 498-510. Reproduced in *Statistical Policy in Less Developed Countries*, IDS Communication 114, 1975. French version: *Economie et Statistique*, no. 75 (1976) 21-26. Hungarian translation: *Demográfia XVIII* (1975): 467-478.

152. The expanding frontiers of input-output analysis. Paper presented at the 40<sup>th</sup> Session of the International Statistical Institute, Warsaw, 1975. *Bulletin de l'Institut International de Statistique* XLVI (1975): 306-321.
153. Modelling the educational system. Paper presented at a Research Planning Conference on the Demography of Educational Organizations, Cambridge, Mass., 1975.
154. Introduction to *Social Accounting Methods for Development Planning: a Case Study of Sri Lanka* by Graham Pyatt, Alan R. Roe, and associates. Cambridge University Press, 1977.
155. Direct and indirect constraints in the adjustment of observations. In *Nasjonaltregnskap, Modeller og Analyse* (essays in honour of Odd Aukrust), Statistisk Sentralbyrå, Oslo, 1975.

## 1976

156. Major accounting problems for a world model. Paper presented at a working seminar on Global Opportunities and Constraints for Regional Development, Harvard University, Cambridge, Mass., 1976, In *Problems of World Modeling*, Ballinger, Cambridge, Mass., 1977. Hungarian translation: *Demográfia* XX (1977): 23-55.
157. Michael James Farrell (obituary). *Annual Report of the Council of King's College, Cambridge*, 1976, pp. 34-36.
158. Abraham Aidenoff, 1913-1975 (obituary). *International Statistical Review* 44 (1976): 383-384.

## 1977

159. The evolution of the Cambridge Growth Project. Lecture given at the Institut für Siedlungs- und Wohnungswesen der Westfälischen Wilhelms-Universität Münster. In *Beiträge zur Strukturpolitik*, Materialien zum Siedlungs- und Wohnungswesen und zur Raumplanung, no. 18, Münster. Hungarian translation: *Statistikai Szemle* 56 (1978): 236-249.
160. Introduction to *Inland Revenue Report on National Income, 1929*, Department of Applied Economics, University of Cambridge, 1977
161. Introduction to *Econometric Contributions to Public Policy*, the proceedings of a conference held by the International Economic Association, Urbino, 1976. Macmillan, London, 1978.
162. Harry Gordon-Johnson (obituary). *Annual Report of the Council of King's College, Cambridge*, 1977, pp. 24-26.
163. Discussion of Professor Abramovitz's paper on rapid growth potential and its realisation: the experience of capitalist economies in the postwar period. Presented at the Fifth World Congress of the International Economic Association, Tokyo, 1977. In *Economic Growth and Resources, Vol. 1, The Major Issues*. Macmillan, 1979, pp.34-44.

## 1978

164. Introduction to *Towards a Methodology for Projecting Rates of Literacy and Educational Attainment*. UNESCO, Paris, 1978.
165. The disaggregation of the household sector in the national accounts. Paper presented to the World Bank SAM Conference, Cambridge, England, 1978. In *Social Accounting Matrices: a Basis for Planning*, G. Pyatt and J.I. Round (eds.), The World Bank, Washington, D.C., 1985.
166. Multipliers for Quesnay's tableau. In *Social Accounting Matrices: a Basis for Planning*, G. Pyatt and J.I. Round (eds.), The World Bank, Washington, D.C., 1985.
167. Keynes, political arithmetic and econometrics. Keynes Lecture in Economics, 1978. In *Proceedings of the British Academy*, vol. LXIII, 1980, and separately.
168. Input-output analysis and economic planning: a survey. Paper presented at the International Symposium on Mathematical Programming and Its Economic Applications, Venice, 1978. In

- Mathematical Programming and Its Economic Applications*, Angeli, Milan, 1981.
169. Jacob Marschak, 1898-1977 (obituary). *Journal of the Royal Statistical Society, Series A (General)* 142 (1979): 80-81.
170. Tribute to Luigi Solari. Address presented to the European Meeting of the Econometric Society, Geneva, 1978. In *Qualitative and Quantitative Mathematical Economics*, J.H.P. Paelinck (ed.), Nijhoff, The Hague, 1982.
171. Can matrix multipliers be decomposed in the general case? Unpublished manuscript.
172. Where are we now? A short account of the development of input-output studies and their present trends. Paper presented at the Seventh International Conference on Input-Output Techniques. Innsbruck, 1979. In *Proceedings of the Seventh International Conference on Input-Output Techniques* (ed., UNIDO), UN, New York, 1984. Russian translation: *Economics and Mathematical Methods XV* (1979): 1094-1109. Hungarian translation: *Statisztikai Szemle* 63 (1985): 555-570.
173. Sigmoids. Opening address to the Royal Statistical Society Conference Oxford, 1979. *Bulletin in Applied Statistics (B.I.A.S.)* 7 (1980): 59-119.
174. *Aspects of Economic and Social Modelling*. Lectures delivered at the University of Geneva, 1979. Droz, Geneva, 1981.

## 1980

175. A simple growth process tending to stationarity. *The Economic Journal* 90 (1980): 593-597.
176. The relationship of demographic accounts to national income and product accounts. Paper presented to the SSRC Workshop on Social Accounting Systems, Washington, D.C. 1980. In *Social Accounting Systems: Essays on the State of the Art*. F. Thomas Juster and Kenneth C. Land (eds.), Academic Press, New York, 1981.
177. The adjustment of observations. Unpublished manuscript.
178. Whittling away at the residual: some thoughts on Denison's growth accounting. A review article. *Journal of Economic Literature* XVIII (1980): 1539-1543.
179. Political economy, economics and beyond. Royal Economic Society, Presidential Address 1980. *The Economic Journal* 90 (1980): 719-736.
180. A marital status transition matrix: England and Wales, 1972, males. Unpublished manuscript.
181. Model design and simulation. *Economic Modelling* 1 (1984): 3-23.
182. Random shocks in a simple growth model. *Economic Modelling* 1 (1984): 277-280.

## 1981

183. Balancing the national accounts: the adjustment of initial estimates – a neglected stage in measurement. In *Demand, Equilibrium and Trade*, A. Ingham and A.M. Ulph (eds.), Macmillan, London, 1984.
184. The international harmonisation of national income accounts. *Accounting and Business Research* 12 (1981): 67-79.
185. Life profiles and transition matrices in organizing sociodemographic data (appendix to "Active life profiles for different social groups" by Dudley Seers). In *Economic Structure and Performance*, Academic Press, San Diego, 1984.
186. Working with what we have: how can existing data be used in the construction and analysis of socio-demographic matrices? *The Review of Income and Wealth, Series 28*, no. 3 (1982), 291-303.

## 1982

187. How accurate are the British national accounts? In *Specification Analysis in the Linear Model*, Maxwell L. King and David E.A. Giles (eds.), Routledge and Kegan Paul, London, 1987.

### 1983

188. Accounting matrices in economics and demography. In *Mathematical Methods in Economics*, F. van der Ploeg (ed.), Wiley, New York, 1984.

### 1984

189. Two populations and their economies (with M. Weale). Paper presented at the Annual Conference of the Regional Science Association, Canterbury, 1984. In *Integrated Analysis of Regional Systems*, P.W.J. Batey and M. Madden (eds.), London Papers in Regional Science 15. Pion, London, 1986.
190. Robert Malthus. Address to Conference of the British Society for Population Studies, Cambridge, 1984. In *The State of Population Theory*, D. Coleman and R. Schofield (eds.), Blackwell, Oxford, 1986.
191. The accounts of society. Nobel Memorial Prize Lecture, 1984. In *Les Prix Nobel 1984*, Almquist and Wicksell International, Stockholm, 1985, reprinted in *Journal of Applied Econometrics* 1 (1986): 5-28.
192. Richard Stone (an autobiographical sketch). In *Les Prix Nobel 1984*, Almquist and Wicksell International, Stockholm, 1985.

### 1985

193. Foreword to *Materials for a Balance of the Soviet National Economy, 1928-1930* (transl. and eds. S.G. Wheatcroft and R.W. Davies). Cambridge University Press, 1985.
194. James Alan Calvert Brown: an appreciation. *Oxford Bulletin of Economics and Statistics* 47 (1985): 191-197.
195. Entries on: the Matrix Multiplier; R.G.D. Allen; A.L. Bowley; R.C. Geary; M.G. Kendall; E. Rothbarth; and J.C. Stamp. In *The New Palgrave*, Macmillan, London 1987.

### 1986

196. Social accounting: the state of play. *The Scandinavian Journal of Economics* 88 (1986): 453-472.
197. Progress in balancing the national accounts. In *National Income and Economic Progress*, D. Ironmonger, J. Perkins and Tran Van Hoa (eds.), Macmillan, London, 1988.
198. *Some British Empiricists in the Social Sciences 1650-1900*. Mattioli Lectures, delivered by Richard Stone at the Università Commerciale Luigi Bocconi, Milano, October 1986. Edited by A. M. Cardani and G. Stone, and published posthumously. Cambridge University Press, Cambridge, 1997.

### 1987

199. When will the war end? *Cambridge Journal of Economics* 12 (1988): 193-201.
200. Some seventeenth century econometrics: consumers' expenditure. Solari Lecture, 1987. *Revue européenne des sciences sociales* XXVI (1988): 19-41.

## 1988

201. Some seventeenth century econometrics: public finance. Lecture for the Ninth Centenary Celebrations of the University of Bologna. *Revue européenne des sciences sociales* XXVII (1989): 5-32.
202. Adjusting the national accounts. Lecture presented at the Central Institute of Statistics, Rome, September 1988. To be published.
203. The national accounts today and tomorrow. *Rivista di Politica Economica* LXXIX (1989): 3-38.

## 1989

204. The theory of games revisited. Published in *Economic Journal* Special Issue Centenary Volume of the Royal Economic Society (1990).
205. Professor Sir John Hicks (obituary). *The Caiian: The Annual Record of Gonville and Caius College, Cambridge*, November 1989, pp. 100-105.

## 1990

206. Public economic policy: Adam Smith on what the state and other public institutions should and should not do. Paper presented at the Conference for the bicentenary of Adam Smith's death, Edinburgh, July 1990. Published in *Adam Smith's Legacy*, Routledge, London, New York (1992).