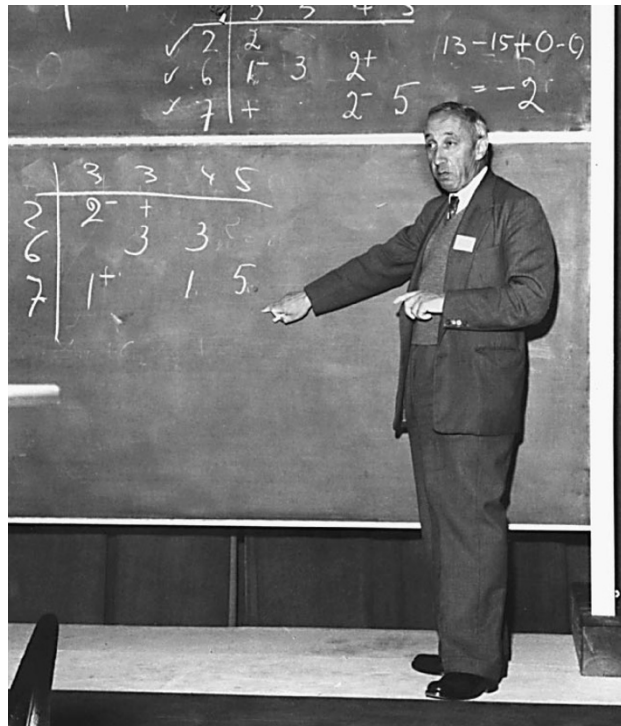# The work of Professor Steven Vajda 1901–1995

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Steven Vajda, who died in Brighton on 10 December, 1995, played a major part for 50 years in the development in Britain of OR in general and Mathematical Programming in particular. He was a companion of the OR Society as well as having received the Silver Medal of the Society. He was an honorary member of the Institute of Actuaries and a Fellow of the Institute of Mathematical Statistics. This article is based partly on personal recollections and partly on information obtained from others.

It is daunting to think back to Steven Vajda's early life in a world which has since been transformed both politically and technologically. This is outside the experience of almost everybody alive today. Steven was born in Budapest in 1901 but soon moved with is family to Vienna. After training as an Actuary he went on to study mathematics and take his doctorate at Vienna University. At this time, between the wars, Vienna was a hive of intellectual activity. Steven knew and studied with many of the most original thinkers of this century: Carnap and Schlick, philosophers of the Vienna circle, Popper the philosopher, Gabor, the inventor of the hologram and Gödel the discoverer of the famous undecidability theorems of mathematics. I (HPW) can remember occasional conversations I have had with Steven (on buying a hologram for my daughter in Amsterdam or discussing the relationship between Integer Programming and Logic) in which these names would come up with recollections and sometimes the admission 'they were a bit younger than me'. These experiences gave him the great breadth of knowledge and intellectual curiosity which were such a striking feature of his personality.

In 1938 Austria capitulated to Hitler (the Anschluss). Steven's children, Hedy aged 8 and Robert aged 5 were dispatched to Sweden. Later Steven's wife Eva fled to England where she was reunited with her children and supported herself in domestic service. Through Karl Popper, Steven arranged to emigrate to New Zealand but to go via England in order to collect his family. He was

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allowed to stay in England. I (HPW) can remember Steven explaining these events to me by reason of the fact that 'Hitler didn't like me very much, but then I didn't like him very much either'.

Most OR people will not be aware that before leaving Austria, Steven contributed to the development of Actuarial Science and published a number of articles (in German). His interest in Actuarial Science, as well as providing him with his first employment in Britain, stayed with him for the rest of his life and is reflected in some of his later publications (see References 14, 16, 39, 41). He continued to attend actuarial conferences and frequently acted as a simultaneous translator.

Three months after arriving in this country Britain declared war on Germany and Steven, as an alien, was interned on the Isle of Man. He described the internment camp as a 'mini-university'. Many of the inmates such as Claus Moser and Peter Landsberg were still boys and can recall being taught Mathematics by Steven. It was soon realised that Steven was not a threat to the security of this country and he was released. After working in an Insurance company he was, in 1944, recruited into the Admiralty Research Laboratory at Teddington. Later he was to become Head of Mathematics followed by Head of OR. Again his influence on others was significant. He recruited Martin Beale and others into the Admiralty and publicised and communicated the newly emerging subject of Linear Programming. The recognition of the relationship with Game Theory (being developed by Von Neumann) and the many potential applications caused Steven great excitement which he conveyed to others through his clear expositions. Also he became fascinated by the underlying duality which manifested itself in both Linear Programming and Game Theory. His book on *The Theory of Games and Linear Programming*, published in 1956 (Reference 22) was the first book on the subject and was translated into German, French, Japanese and Russian.

The book has been reprinted many times as a popular paperback. It explains the connection (and interchangeability) between 2-Person Zero-Sum Games and Linear Programming clearly and succinctly by algebraic, numerical and geometrical examples. To many in Europe (and the East) this was their first introduction to the subject and a revelation that the subjects were so closely connected. Steven was particularly interested in *Duality* which is central to Linear Programming and has, of course, an obvious interpretation in Economics (Marginal Values), Computational Optimisation (proofs of Optimality) and Combinatorics (proofs of the theorems of König, Dilworth and Menger). Steven was not only probably the first person in Britain to understand these connections, he also was brilliant at communicating them and motivated by genuine intellectual excitement. These results are particularly reflected in other books (References 25 and 26) which have served as textbooks on many university and industrial courses.

He was an essential contributor to all courses on Linear Programming and was instrumental in establishing a regular one-week residential programme at Southfield (University of Birmingham) in 1955. In the Autumn of that year he offered a 10 week evening course at the then Northampton Polytechnic on the subject of Operational Research. His ability to hold an audience's attention and as a tribute to his own stamina is well seen by the many occasions at Cranfield where he gave 4 one and a half hour lectures and followed them with an after dinner talk.

As well as communicating and contributing to the emerging theory of Mathematical Programming, Steven and others (related) mathematical interests. He was interested in other problems in Finite Mathematics (Group Theory, Geometry, Cryptography and Experimental Design). These interests are reflected in References 28 and 29 which again units a number of different mathematical topics, although there is often a (hidden) link to Mathematical Programming which is brought out in the publication. Another interest which periodically re-emerges at a number of times in his life is the mathematics and applicability of Fibonacci and Lucas Numbers and the Golden Section. This subject, is of course, closely connected with Biology and Aesthetics. Steven's interest here (reflected in References 39 and 42) was akin to that of a Pure Mathematician where he lists and proves numerous mathematical relationships. Again, however, there is a connection with Mathematical Programming. Fibonacci and Golden Mean Searches are optimal methods of enumerating trial values in non-linear optimisation.

An excellent account of these interests is given in the last book he published (Reference 45) with Brian Conolly. Further developments are given in the issue of the Journal of the OR Society celebrating his 90th birthday (Reference 52).

Within Mathematical Programming Steven Vajda's interests were wide. Among other topics on which we have heard him talk and which are reflected in his books are: Dynamic Programming and its connection with Control Theory and the Calculus of Variations, The Trimloss Problem, the Knapsack Problem, Decomposition, Fractional Programming and Steiner Minimal Times.

Another interest which emerges at different points in his publications is Manpower Planning. He applied Linear Programming and Markov Processes to planning manpower over time (References 38 and 39). In particular, interesting mathematical structures emerged. I (HPW) remember one occasion at Sussex University when I managed to solve one of his manpower models with a preprocessing procedure I had developed (and so avoid the Simplex Algorithm) only to show it to be unbounded (usually an indication of a 'nonsensical' model). It turned out that he had given me the dual model as being (rightly) easier to solve and in this case therefore prove that the original was infeasible (required manpower levels were unattainable).

His pioneering influence on education and the direction of Master's courses was recognised by the University of Birmingham in 1958 when they appointed him (together with B.H.P. Rivett and Sir Charles Goodeve) to the then highest position of honorary lecturer. They advised on the principles of the programme. It was some 7 years later that he was elected to the Chair of Operational Research at Birmingham at the age of 64. Once more his enthusiasm and ability was to inspire a new generation of students and even his formal retirement in 1968 merely led to a range of Senior Research Fellowship appointments first in Statistics and then in Transportation.

His wisdom and humanity was a source of guidance for me (KBH) and for two decades from 1955 and he retained an interest in the progress of Birmingham and his personal friends for the last twenty years.

In 1973 Steven 'retired' again to Sussex University where he remained for 20 years. He first of all joined the OR Group. When this disbanded he joined the Statistics group. For all this time he contributed to teaching and seminars proving a very stimulating companion. He was always extremely interested in what others were doing.

When EURO honoured Martin Beale with a posthumous Gold Medal it was Steven who accepted this with a full paper which contained many new ideas and reflected his concern.

In February 1995, together with Susan Powell and Jacob Krarup, we organised a special event at LSE in honour of Steven and chaired by Ailsa Land. A series of talks were given on the theme of Duality with Steven explaining the economically motivated algorithm of Kantorovitch and contrasting it with Dantzig's Simplex algorithm. I (HPW) well remember Steven's intervention in my talk when I constructed two types of duality, that of Linear Programming and that of polarity between convex polyhedra. 'Doesn't this lead to pairs of games, each with competitors producing dual Linear Programmes' I think it does. The papers given appear in a special edition of the Journal of the Institute of Mathematics and its Applications (Reference 44). That day finished with a very successful dinner with Steven and his daughter as Guests of Honour.

The last time we saw Steven together was the summer of 1995 at the EURO conference in Israel. He seemed to be at all the sessions on Linear Programming and Game Theory as well at many of the Social Events. He was travelling independently and was last seen (KBH) sitting in front of a minibus leaving for the airport and planning to visit Vancouver for the IFORS meeting the following year. This was not Steven's last trip abroad for he took a long coach trip around Spain later that summer followed by a trip to Cornwall for Betty Beale's birthway in September. He died in 1995.

Steven was not just highly intelligent he was intellectually very curious about almost every subject but particularly mathematics and politics. This curiosity combined with his skills of communication (he spike many languages) enabled him to inspire many others into original discoveries and to influence events.

Other accounts of Steven Vajda's life and work can be found in the Reference Section.

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