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In Memoriam

STELLA DAFERMOS, 1940-1990

On April 5, 1990, Stella Dafermos, the original Guest Editor of this special issue on Network Equilibrium, passed away. As a small tribute to her and to her pioneering contributions to the field of transportation science, we completed the editorial process, and are dedicating the special issue to her memory.

Stella Dafermos was born on April 14, 1940, in Athens, Greece, and received her undergraduate degree in Civil Engineering in 1964 from the National Technical University in Athens. She then accompanied her husband, Constantine Dafermos, to Johns Hopkins University in Baltimore, Maryland, and shortly thereafter enrolled in the doctoral program there in Operations Research.

Her 1968 doctoral dissertation, "Traffic Assignment and Resource Allocation in Transportation Networks," supervised by F. T. Sparrow, focused on the formulation, analysis, and computation of system-optimized and user-optimized transportation networks. With her dissertation, she initiated a theme that was to pervade her subsequent research—the development of rigorous mathematical formalisms for the study of equilibrium problems.

In a series of papers in the 1970s, several of which were published in *Transportation Science,* Stella developed network models of user-optimized transportation systems that allowed for interactions among travelers via the link cost functions. She also proposed convergent equilibration algorithms for the determination of the equilibrium flow patterns. In addition, she focused on the use of tolls in order to make the system-optimizing pattern, user-optimizing as well. These network equilibrium models, as well as the integrated models that allowed for both location and route choice, developed in her paper, "Integrated Equilibrium Flow Models for Transportation Planning," in *Lecture Notes in Economics and Mathematical Systems,* Volume 118, 1976, were formulated as optimization problems, with the observation that the equilibrium conditions governing these problems were actually the Kuhn-Tucker conditions of an appropriately constructed optimization problem. In order for such a reformulation to be possible, the assumption of symmetry, in which the cross-effects of various interactions had to be identical, had to be imposed.

Interestingly, in parallel to the developments in network equilibrium methodology in transportation science, economists and regional scientists had come to realize by then the importance in trade of spatial configurations, along with associated transportation costs. They had begun studying spatial price equilibrium problems, reformulated as optimization problems. The symmetry assumption, however, precluded the realistic modeling of multiple modes of transportation and of different classes of users of the transportation system in the context of traffic network equilibrium problems, as well as of multiple commodities in the context of spatial price equilibrium problems.

Stella, in a paper published in this journal in 1980, "Traffic Equilibrium and Variational Inequalities," made a far-reaching and fundamental discovery in noting that the traffic equilibrium conditions, as formulated by M. Smith, were actually a variational inequality problem. Although the theory of variational inequalities had been introduced more than a decade earlier for the study of partial differential equations, that usually arise in mechanics, the emphasis in that literature was on infinite-dimensional problems. The use of variational inequality theory as a powerful tool in equilibrium analysis and computation was unexplored in operations research and transportation science.

This path-breaking paper was followed by papers that appeared in *Transportation Science* and in *Networks* in which Stella introduced general network equilibrium models, including a multimodal model with elastic demands, for which no equivalent optimization formulations of the equilibrium conditions were available and proposed variational inequality based algorithms, such as the projection method and the relaxation method for their solution.

In 1983 she introduced in a paper in *Mathematical Programming,* a general iterative scheme for solving variational inequality problems. The scheme in its various realizations has been applied to compute the equilibria in problems ranging from traffic network problems and spatial price equilib-

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rium problems, to spatial oligopolistic markets in which firms operate in a noncooperative manner, to Walrasian price and general economic equilibrium problems.

In papers on sensitivity analysis, motivated by certain paradoxical phenomena occurring in user-optimized networks originally identified by Braess, Stella and her doctoral students established stability results and showed how the systems could be expected to react to changes in the initial data. This research culminated in a 1988 paper in *Mathematics of Operations Research* that provided a framework for sensitivity analysis for variational inequality problems.

Stella did not serve the profession only through her research contributions. She was also an Associate Editor of *Transportation Science* and *Networks*, and a Council Member of the Transportation Science Section of ORSA. After an initial appointment in the Department of Industrial Engineering and Operations Research at Cornell University, she joined the faculty of Brown University in Providence, Rhode Island, in 1972, where she became a Professor of Applied Mathematics and Engineering. At Brown she taught operations research courses at both the undergraduate and graduate levels and developed an undergraduate course in transportation. Many of the undergraduates who took that course later obtained doctorates in operations research.

Stella was a recipient of the National Science Foundation Visiting Professorship for Women Award, which she spent as a Visiting Professor in the Transportation Systems Division in the Department of Civil Engineering at the Massachusetts Institute of Technology, Cambridge during the 1984-1985 academic year. She had also held visiting appointments at the University of Wisconsin, Madison, and at the National Technical University of Athens, Greece.

Stella is survived by her husband, the Alumni-Alumnae University Professor of Applied Mathematics at Brown University, by two teen-aged children, Michael and Thalia, and by her parents and brother in Athens.

It is hoped that this special issue on Network Equilibrium is in the spirit that Stella Dafermos had intended when she agreed to act as its Guest Editor. It is with deepest respect that we honor her in this way.

AMEDEO ODONI and ANNA NAGURNEY

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