



NEW CONCEPTS AND TRENDS OF MCDM FOR TOMORROW – IN HONOR OF PROFESSOR GWO-HSHIUNG TZENG ON THE OCCASION OF HIS 70th BIRTHDAY

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Abstract. This article introduces several new concepts and trends in multiple criteria decision making (MCDM) for solving actual problems, as proposed by Professor Gwo-Hshiang Tzeng. These new concepts are as follows: (1) interdependency in real-world problems; (2) replacing the relative good solution from the existing alternatives using aspiration levels; (3) shifting from ranking and selection to performance improvement; (4) information fusion/aggregation; and (5) changeable decision spaces. To honor Prof. Tzeng's contribution in the MCDM field and to commemorate his 70th birthday, this article also highlights his research career in MCDM and some publication list in the past 10 years.

Keywords: MCDM, MADM, MODM, DEMATEL, DANP, VIKOR, Changeable space, Aspiration level.

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1. New trends and concepts in MCDM

Over the past two decades, the development of information technology (IT) has been characterized by a series of positive, but temporary, shocks. The alternate perspective is that IT in Internet communication has produced a fundamental change in the world, leading to a permanent improvement in fast growth-change prospects such as telephone, telegraph, Internet, smart phone, i-phone, i-pad, cloud computing, business, economy, society, and government. What are the prospects for future trends? Which problems will be solved regarding user/customer/societal needs in marketing situations, and how can overall problems in dimensions and criteria be resolved using aspiration levels? The traditional MCDM field ignored some important new concepts and trends and needed several assumptions to solve real-world problems. Therefore, Prof. Tzeng proposed some new concepts for facing tomorrow's world.

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First, the traditional model assumes that the criteria in value-creation are independent and hierarchical in structure; however, criteria are often interdependent in real-world problems because 'Some statistics and economics assumptions are unrealistic in the real world'. The Decision Making Trial and Evaluation Laboratory (DEMATEL) technique is an effective tool to find the interrelationship matrix and building an influential network relation map (INRM) for solving relationship problems in the real world. Second, the relatively good solution from existing alternatives is replaced by aspiration levels to avoid "Choosing the best among inferior options/alternatives", i.e. "Picking the best apple among a barrel of rotten apples". Third, the emphasis in the field has shifted from ranking and selection when determining the most preferable approaches to performance improvement of existing methods based on INRM because "we need a systematic approach to problem-solving; instead of addressing the systems of the problem, we need to identify the sources of the problem". Fourth, Kahneman and Tversky (Kahneman received the Nobel Prize in Economics in 2002) developed the basic concept of the non-additive (or super-additive) value-function aggregation in multi-criteria problems in 1973. Simon incorporated the basic concept of the "aspiration level" in his work, receiving the Nobel Prize in Economics in 1978. The question that arises is "How can we implement these two concepts (non-additive value function and aspiration level) within real-world inter-relationship (dependence and feedback) problems?" Information fusion or aggregation/integration such as fuzzy integrals (basically, a non-additive or super-additive model) has been developed to aggregate/integrate performances. Therefore, to overcome the defects of the conventional Multiple Attributes Decision Making (MADM) method, a new Hybrid Dynamic Multiple Criteria Decision Making (HDMADM) method has been developed for solving complicated and dynamic problems in the real world and application to improve real issues, e.g. Internet communication, government overall policy improvement, etc. Fifth, classical Multiple Objectives Decision Making (MODM) methods are used to pursue an optimal solution in a fixed feasible region (objective space) based on fixed conditions or resources (decision space). A new thinking of MODM models with changeable spaces can help decision-makers reach a win-win for planning/designing and achieve the desired point (aspiration level), which is better than pursuing the ideal point or Pareto optimal solution.

2. Profile of Professor Gwo-Hshiung Tzeng

Prof. Gwo-Hshiung Tzeng was born in 1943 in Taiwan as the third child of a poor farmer. While still in his mother's womb, his father worked at the Mitsui Mining Company as the Director of the Manila (Philippine) Branch during World War II. His father (with all his employees) was drafted into the Japanese army to join the war, but never came back. As such, Prof. Gwo-Hshiung Tzeng never saw his father. He was raised by his mother and his grandparents in the difficult period of a ruined Taiwan after World War II.

In 1967, he received a Bachelor's degree in business management from the Tatung Institute of Technology (now Tatung University), Taiwan. In 1971, he received a Master's degree in urban planning from National Chung Hsing University (now National Taipei University), Taiwan. During his studies in Taiwan, he was enlightened by many excellent professors, such as Professor Lai-Chyan Yu (Chairman of the Department of Business Management, Economics),



Professors Cheng-Chen Chen (Econometrics and Statistics) and Fu-Cheng Liu (Logic and Reasoning) from Taiwan University, and Professor Deng-Yuan Huang (Mathematic Analysis) from Academia Sinica, the preeminent academic institution in Taiwan. Through their guidance, Prof. Gwo-Hsiung Tzeng built a strong foundation in economics, mathematics, and statistics. He then worked in the Department of Transportation and Communication in Taiwan after receiving his Master's degree. From 1971 to 1973, he helped to build the first freeway during the economic recovery of Taiwan and also published his first book *Introduction to Modern Statistics*. As a result of his brilliant performance, he received financial support through research projects at Osaka University of Japan for further study in 1973.

In his Japanese study, he served under the direction of Prof. Yutaka Suzuki from Osaka University and Prof. Tamotsu Yokoyama from Tokyo University. Because of Prof. Suzuki's electrical system engineering background (40 years ago a member of the Club of Rome's report Limits to World Growth for World Dynamic Systems) and Prof. Tamotsu Yokoyama, whose majors were statistics, mathematics, operations research, and decision science (Prof. Yokoyama built the society of Operations Research of Japan about 60 year ago), Tzeng learned the importance of integrated sciences. During this period, in the first energy crisis of 1973, he joined or performed many interdisciplinary research projects, such as: "Regional Administrative Organization Decision-Process by PATTERN Method for Application Research" (Kansai Institute of Information System Research Report, March 1975); "Enterprise and Environment: The Location of Business from the View-Point of National, Social, Institutional-Environment" (Kansai Institute of Information System Research, March 1976); and "Survey Research on the Local Administration for Administrative Needs of Regional Residents (Science Research Institute, March 1977), these forming the first steps toward his current research. Fortunately, he also entered a joint project between Tokyo University, Osaka University, Kyoto University and Kobe University. That project helped Japan survive the first energy crisis and suggested many important decisions based on multiple viewpoints for industry development (economics), energy saving, environment protection and society needs. This formative experience triggered his interest in studying various fields and helped inspire his work in MCDM. Within all of these disciplines, Prof. Tzeng gained very high visibility because of his deep and thorough

knowledge on a diverse range of topics. He also established theoretical backgrounds in soft computing, evolutionary computing and logic reasoning for his future MCDM research. At the same time, fuzzy set theory was flourishing in Japan. Under the direction of several internationally acknowledged professors (Hideo Tanaka, Masatoshi Sakawa, Masaharu Mizumoto, etc.), Tzeng published numerous journal papers in economics, urban planning, hospital management and many cross-field papers.

In 1977, Prof. Tzeng received his PhD degree in management science from Osaka University, Japan. He then returned to Tatung University in Taiwan as an Associate Professor for one year; then, he taught at National Chiao Tung University, Taiwan, from 1978 to 1981. Subsequently, Prof. Tzeng was a research associate at Argonne National Laboratory from 1981 to 1982, a visiting professor in the Department of Civil Engineering and Business School at the University of Maryland, College Park, from July 1989 to August 1990, and a visiting professor in the Department of Engineering and Economic System, Energy Modeling Forum at Stanford University from July 1997 to September 1998. These international experiences widened his global perspective.

During the time that Prof. Tzeng was at Argonne National Laboratory, the second worldwide energy crisis took place. He joined the energy and pollution effort and studied energy issues in transportation, family, business and industries. Upon returning from the United States, he created a Society of Energy Economics in Taiwan and joined a Chapter of IAEE (International Association for Energy Economics). He further helped Taiwan become a member of the World Energy Congress. He also learned “Habitual Domain” and “Competence Set Expansion” from Carl A. Scupin Distinguished Professor Po Lung Yu beginning in 1985. Later, in 1992, he and Professor Yu built a Society of Habitual Domain in Taiwan where he was the President for over 10 years. He advanced to a full professor at National Chiao Tung University during 1981 to 2003 and assumed the position of Chair Professor at National Chiao Tung University. He received the title of National Distinguished Chair Professor (the highest honor offered by the Ministry of Education Affairs, Taiwan) and Distinguished Research Fellow (Highest Honor Offered by NSC, Taiwan) in 2000. During his more than 30 years as a professor, he devoted his energy to areas of research, industry, government service and education. Prof. Tzeng consistently played a vital role in MCDM for management sciences, applying it to economics and business in Taiwan.

In addition to his enormous achievements in energy and transport policies of Taiwan and his wide and varied research activities, Prof. Tzeng was always a dedicated and enthusiastic participant in the education of students and researchers. His enthusiasm and magnetism were apparent to students when his lectures on research methods often continued until after 5 or even 6 o'clock, extending beyond the scheduled ending of the class by more than one or two hours. He has mentored (either directly or indirectly) over 100 doctoral dissertations, and over 200 of his graduate students completed their MS thesis studies. Some of his former graduate students and former postdoctoral scholars are now actively working in as high-ranking officers in government, entrepreneurs in industry and scholars in academia. In the teaching and training of young researchers, he always emphasized the importance of integrated knowledge and aspiration levels. His motto is: “Avoid picking the best apple among a barrel of rotten apples and pursue a high aspiration level rather than just a relatively good one.” Prof. Tzeng appeared to be a superman in his diligence when trying to resolve a problem. Almost every student has received a call from him at midnight when he was so excited by finding a solution that he wanted to share the results. He has written many books, such as

Introduction to Modern Transportation Theory and Applications, Statistics, and Multivariate Theory and Applications (three volumes and the first Chinese book regarding multivariate analysis). Recently, he completed two books in English: *Multi Attributes Decision Making* and *Fuzzy Multiple Objective Decision Making* published by Taylor & Francis (see Annex).

In addition to his extensive teaching accomplishments, Prof. Tzeng has received numerous distinguished achievements for his research. His research interests are wide-ranging and include statistics, multivariate analysis, network, routing and scheduling, multiple criteria decision making, fuzzy theory, hierarchical structure analysis for applying to technology management, energy, environment, transportation systems, transportation investment, logistics, location, urban planning, tourism, technology management, electronic commerce, and global supply chains. His paper “Compromise solution by MCDM methods: a comparative analysis of VIKOR and TOPSIS”, as published in the “*European Journal of Operational Research*” on July 16th, 156(2): 445–455, 2004, was noted as being a Highly Cited Paper on March 13th by ESI and has been recently identified by Thomson Reuters’ *Essential Science Indicators*SM to be one of the most cited papers in the field of Economics. His papers were cited over 2000 times in 2012 according to Google Scholar¹.

He received the MCDM Edgeworth-Pareto Award from the International Society on Multiple Criteria Decision Making (June, 2009), the Pinnacle of Achievement Award 2005 of the world, and the National Distinguished Chair Professor, the Award (the highest honor offered) of the Ministry of Education Affairs of Taiwan, three times the award of distinguished research and two times the award of distinguished research fellow (highest honor offered) of National Science Council of Taiwan. The 10th MCDM Conference was organized by G. H. Tzeng and P. L. Yu in Taipei at the Asiaworld Plaza Hotel in July 19–24, 1992. The theme of the conference was “Expand and Enrich the Domains of Thinking and Applications”. This conference is highly publicized in Taiwan. The conference attracted more than 300 people from 34 countries. He raised a large amount of money from sponsors and was able to host one of the grandest conferences, with a wonderful social program. The awards tradition started at this conference. The Gold Medal was awarded to Stanley Zionts, the Edgeworth-Pareto Award jointly to Po-Lung Yu and Milan Zelney, and the George Cantor Award was awarded to Andrzej Wierzbicki, all of whom were pioneers of MCDM. He has been a member of society of MCDM committee for many years. He came to know many foreign scholars in the MCDM field (e.g. Po-Lung Yu, M. Zeleny, David Bell, Valerie Belton, Harold Philip Benson, Denis Bouyssou, Jared L. Cohon, William Wager Cooper, Kalyanmoy Deb, James Dyer, Ward Edwards, Peter Fishburn, Tomas Gal, Arthur Geoffrion, Yacov Haimes, Raimo P. Hamalainen, Ralph L. Keeney, Murat Koksalan, Pekka Korhonen, Oleg Larichev, Alexander Lotov, Roman Slowinski, Benedeto Matarazzo, Salvatore Greco, Jaap Spronk, Ralph Steuer, Yong Shi, Masatoshi Sakawa, Thomas Saaty, Bernard Roy, Carlos Romero, Howard Raiffa, Hirotaka Nakayama, Kaisa Miettinen, Theodor J. Stewart, Philippe Vincke, Jyrki Wallenius, Andrzej Piotr Wierzbicki, and many other excellent scholars). In addition, he organized a Taiwan affiliate chapter of the International Association of Energy Economics in 1984; became Co-Chairman of the 36th International Conference on Computers and Industrial Engineering in June 20–23, 2006, Taipei, Taiwan; and was Chairman of the International

¹ <http://scholar.google.com/citations?user=ZRORvQAAAAJ&hl=en>

Summer School on Multiple Criteria Decision Making 2006 in July 2–14, Kainan University, Taiwan. He is a member of IAEE, ISMCDM, World Transport, the Operations Research Society of Japan, the Society of Instrument and Control Engineers Society of Japan, the City Planning Institute of Japan, the Behaviormetric Society of Japan, the Japan Society for Fuzzy Theory and Systems; and participates in numerous societies in Taiwan. He is also Editor-in-Chief of the International Journal of Information Systems for Logistics and Management. With the continuing input of his graduate students, post-doctoral fellows and research associates, as well as active collaborations with industrial and university researchers, it is expected that Prof. Tzeng's contributions will continue to be both numerous and of major significance to the field. With this paper, we join in wishing him the very best on the occasion of his 70th birthday, and we also wish him continued health and productivity in the years ahead.

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