



**Data Envelopment Analysis International Conference 2018  
Joint with Innovative management Workshop**

**2018 數據包絡分析國際研討會  
暨 創新管理工作坊**

**Conference Handbook**

Jihe Campus, Ming Chuan University

銘傳大學·基河校區

June 13-17, 2018, Taipei, Taiwan

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# 1 Guidelines for Participants

## Conference Host

Ming Chuan University was founded by Dr. Teh-Ming Pao and Dr. Ying-Chao Lee in September 1957, establishing “an educational setting which attends to all students with parental care, support, and guidance” as the educational concept, implementing “honesty, sincerity, humility, and determination” as the university motto, and “striving for excellence, professionalism, and internationalization” as the educational goals. Currently, five strategic initiatives are being pursued for university affairs’ development, including (1) dedicated excellent teaching; (2) key applied research; (3) comprehensive caring counseling; (4) safe and friendly campus; and (5) overseas university accreditation.

On November 18, 2010, Ming Chuan University was accredited by the Middle States Commission on Higher Education (MSCHE), making it the first U.S.-accredited university in Asia. On August 2012, the Ming Chuan University Michigan Location was established. In 2016, the university was re-accredited with MSCHE for the longest allowable period of 10 years. On July 25, 2017, the School of Management was accredited by the Association to Advance Collegiate Schools of Business (AACSB). The engineering-related departments have participated in engineering program accreditation by the Institute of Engineering Education, Taiwan, R.O.C. (IEET) since 2006; seven departments are IEET-accredited, including Computer Science and Information Engineering, Computer and Communication Engineering, Information and Telecommunications Engineering, Electronic Engineering, Biotechnology, Biomedical Engineering, and Architecture.

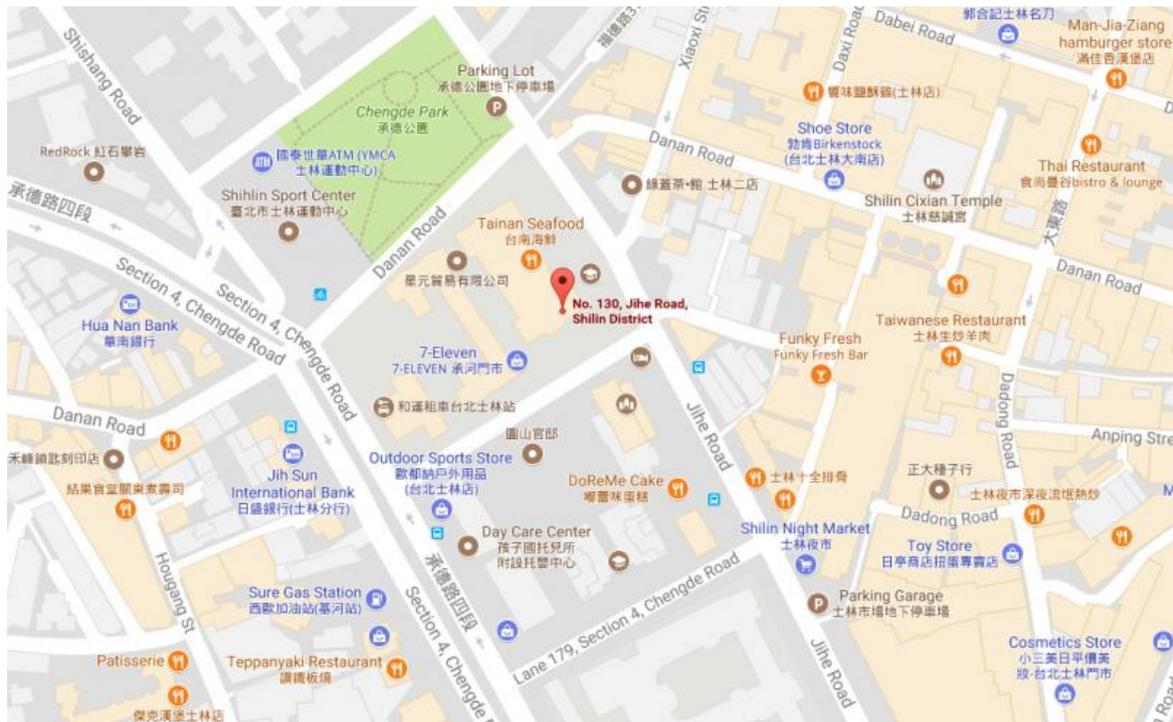
Ming Chuan University has long strived for teaching excellence and was awarded the Ministry of Education Program for Teaching Excellence for 10 consecutive years. In the Ministry of Science and Technology (MOST) College Student Research Projects, Ming Chuan students have earned outstanding 2nd and 3rd place nationwide for 5 consecutive years, which reflects our students’ self-learning and research competency. Ming Chuan University has been honored as an “Outstanding Moral Education University” by Ministry of Education for 5 consecutive years for the civility displayed on its lively campuses and the attention to cultivating healthy, active, and helpful attitudes as Ming Chuan has attained a fine reputation for its friendly campuses. In 2013, Ming Chuan was also accredited with ISO 14001 Environmental Management.



**Conference venue:** Ming Chuan University, Jihe Campus

**Address:** Jihe Complex: 3F. No. 130, Jihe Road, Taipei City

**Telephone: +886 (0)2-2882-4564, extension 8004, 8013**



### **Transportation**

The conference venue is located in the Shilin district of Taipei city, not far from Yangmingshan National Park and Mass Rapid Transit (MRT), Tamshui (red) line, exit 1 of Jiantan station. It is also close to the Shilin Official Residence, the Taipei Fine Arts Museum, and Shilin Night Market. There are bus stops for various bus routes in front of the campus that connect with various famous sights in Taipei. Whether for tours, shopping, or business, fast and convenient transportation service is nearby.

### **Taoyuan International Airport**

It is quite convenient to take public transportation back to the airport from Taipei city. Take the Mass Rapid Transit (MRT), Tamshui (red) line, and exit at Minquan W. Rd. Slightly to the west of the station on Minquan W. Rd. is a stop for the CitiAir Airport bus which runs from 05:00 to 20:30 to the Taoyuan.

### **High Speed Rail**

Take the High Speed Rail to the Taipei Main Station stop and transfer to the Mass Rapid Transit (MRT), Tamshui (red) line, disembark at Jiantan station and use Exit No. 1, walk about 5 minutes to the conference venue.

### **Public Bus**

Ming Chuan Hotel stop: Ho-Hsin bus, 529, 41, Red 9, 620 shuttle bus, Red 30, 290, 303. Walk about 2 minutes after getting off at Ming Chuan Hotel stop to arrive at the conference venue.

### **Parking**

Guest parking is available on B3 level of this building.

## 2 Conference Program

### DAY1 (Wednesday, June 13)

On-site Registration: open 8 a.m.

Participants check-in hotel located in Ming Chuan Hotel

### DAY2 (Thursday, June 14)

Time	Agenda			Venue
09:00~09:05	Opening Ceremony			J616 International Conference Hall
09:05~09:30	Welcome Address by President Chuan Lee, Ming Chuan university			
	Welcome Address by Professor Joe Zhu, Worcester Polytechnic Institute			
09:30~09:45	Group Photo			
09:45~10:00	Coffee break			
10:00~10:50	Plenary Session Keynote Speech Address by Professor Wade D. Cook Topic: Data Envelopment Analysis with Dependent DMUs Host: Tsu-Tan Fu			
	10:50~11:40	Plenary Session Keynote Speech Address by Professor Joseph C. Paradi Topic: DEA Communications, the Good, the Bad and the Ugly Host: Tsu-Tan Fu		
11:40~13:30		Lunch		
13:30~14:20	Plenary Session Invited Speech Address by Professor Sungmook Lim Topic: Primal-dual correspondence and frontier projections in two-stage network DEA models Host: Kun Chen			J616 International Conference Hall
14:30~15:50	Parallel Session 1			
	J505	J506	J507	
	Session 1A Session Chair: Mehdi Toloo	Session 1B Session Chair: Erhan Berk	Session 1C Session Chair: Yin-Sheng Yang	
15:50~16:10	Coffee Break			
16:10~17:30	Parallel Session 2			
	J505	J506	J507	
	Session 2A Session Chair: Wei-Wei Zhu	Session 2B Session Chair: Wei-Jun He	Session 2C Session Chair: Yu Yu	
18:00	Banquet			

**DAY3 (Friday, June 15)**

Time	Agenda			Venue
09:00~09:50	Plenary Session Invited Speech Address by Professor Wen-Bin Liu Topic: DEA Estimation of Directional Scale Elasticity Host: Song Han			J616 International Conference Hall
09:50~10:40	Plenary Session Invited Speech Address by Professor V. Charles Topic: Firm performance versus regional competitiveness and social progress: A quick snapshot Host: Ming-Miin Yu			
10:40~10:55	Coffee Break			
10:55~11:45	Plenary Session Keynote Speech Address by Professor C. Kao Topic: A classification of slacks-based efficiency measures in network data envelopment analysis Host: Shih-Nan Hwang			
11:45~14:00	Lunch			
14:00~15:20	Parallel Session 3			
	J505	J506	J507	
	Session 3A Session Chair: Cheng-Ping Cheng	Session 3B Session Chair: Zhi-Xiang Zhou	Session 3C Session Chair: Ying-Ming Wang	
15:20~15:40	Coffee Break			
15:40~17:00	Parallel Session 4			
	J505	J506	J507	
	Session 4A Session Chair: Sunil Kumar	Session 4B Session Chair: Ashish Chopra	Session 4C Session Chair: Wen-Bin Liu	
17:00~17:30	Closing Ceremony & Announcements of Awards			

**DAY4 (Satday, June 16)**

Time	Agenda			Venue
09:30~10:20	Workshop I			J616 International Conference Hall
10:20~10:40	Coffee Break			
10:40~11:30	Workshop II			
11:30~14:00	Lunch			
14:00~15:20	Workshop III			
15:20~15:40	Coffee Break			
15:40~17:00	Workshop IV			

**DAY5 (Ssun, June 17) Farewell**

### 3 Keynote Speech

Plenary Session

Keynote Speech Address by Professor Wade D. Cook

Topic : Data Envelopment Analysis with Dependent DMUs

Host: Tsu-Tan Fu

## Data Envelopment Analysis with Dependent DMUs

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DEA, developed by Charnes, Cooper and Rhodes (1978) is an optimization tool for measuring the efficiency of each member of a set of decision making units (DMUs) relative the other DMUs in that set. The conventional model assumes that each DMU possess its own set of inputs that generate or result in its own set of outputs . Further, it is assumed that the input and output bundles for any given DMU are in no particular way connected to those of the other DMUs. In more precise terms, the DMUs are assumed to be independent of one another. In some situations, however, the independence assumption may be violated. Specifically, DMUs may be connected through some form of interdependence. Consider, for example, the situation wherein we wish to evaluate the efficiency of each of a set of automobile dealerships located across the country. The input bundle, unique to any given dealership, might include total numbers of vehicles available for sale, size of the maintenance department, numbers of salespersons, and local advertising. What is missing from the input profile is what we term “block ads”. Specifically, sales numbers of any particular auto brand are very much influenced by TV, radio, magazine and newspaper ads. These ads are a form of “common” input, benefiting all dealerships in the vicinity where those ads appear. What can happen as well, is that the ads can vary from one part of the country to the other. This means that the set of all dealerships can be organized into groups, whereby each dealership in a given group has its own dealer-specific inputs and as well benefits from the common set of ads pertinent to that group of DMUs. This presentation discusses situations where the DMU-dependence phenomenon arises and proposed models for evaluating efficiency.

Keywords: DEA, DMU Dependence, Common Inputs, Common Outputs

Plenary Session

Keynote Speech Address by Professor Joseph C. Paradi

Topic : DEA Communications, the Good, the Bad and the Ugly

Host: Tsu-Tan Fu

## **DEA Communications, the Good, the Bad and the Ugly**

**Joseph C. Paradi**, Ph.D, P.Eng, FCAE. Professor Emeritus

Unfortunately, outside academia DEA has not flourished. My theory: Academics are poor "salesmen" because DEA competes with other methods to help organizations find the fortune of increased productivity and output. This presentation is about Convincing executives to adopt DEA and the presentation will be showing approaches that are Good, Bad, and Ugly. If DEA is to flourish, we must sell it better so it is widely adopted. Proven methods and processes are shown and explained.

Note: The unique feature of the presentation will be bi-lingual in that the slides used are all translated into Chinese for a better understanding for the mainly Chinese audience.

Plenary Session

Invited Speech Address by Professor Sungmook Lim

Topic: Primal-dual correspondence and frontier projections in two-stage network DEA models

Host: Kun Chen

## **Primal-dual correspondence and frontier projections in two-stage network DEA models**

**Sungmook Lim**

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**Abstract:** The standard data envelopment analysis (DEA) procedure involves solving a pair of two types of models, multiplier model and envelopment model, and one of the most interesting features of DEA is that these two types of models are equivalent due to duality in linear programming. However, while several prominent network DEA models have been proposed in the literature in multiplier and/or envelopment forms, it is still doubtful or unclear whether and how the same primal-dual correspondence can be retained between the two types of network DEA models as in the standard DEA. To address this issue, we develop an axiomatic derivation of some two-stage network DEA models in this paper focusing on the basic two-stage serial process structure. We define the production possibility set for the basic two-stage serial process based upon some reasonable axiomatic properties. Subsequently we develop envelopment network DEA models using different distance measures, which are then shown to result in well-known existing two-stage network DEA models in the multiplier form.

**Keywords:** data envelopment analysis (DEA), two-stage, frontier projection, efficiency, duality, production possibility set

Plenary Session

Invited Speech Address by Professor Wen-Bin Liu

Topic : DEA Estimation of Directional Scale Elasticity

Host: Song Han

## **DEA Estimation of Directional Scale Elasticity**

**Wenbin Liu**

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In this work we first extend the classical scale elasticity in economics to directional scale elasticity assuming a production function with one output, and then derive directional scale elasticity formula. We then estimate the directional scale elasticity via DEA, and show a real application in research management. Further we discuss how to extend these concepts to the case of multiple-outputs.

Plenary Session

Invited Speech Address by Professor V. Charles

Topic : Firm performance versus regional competitiveness and social progress: A quick snapshot

Host: Ming-Miin Yu

## **Firm performance versus regional competitiveness and social progress: A quick snapshot**

**V. Charles**

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In the era of data science, measurement and analytics play a vital role in extracting greater insights for public and social good. A plethora of indices have been proposed to measure the regional performance of economies. In this paper, we are interested in computing the indices of regional competitiveness and social progress of Peru, as well as we attempt to measure the regional level performance of the firms from various sectors (considering micro, small, medium and large size firms). We compare and contrast these results in view of the landscape of the country, as well as we look into the 'paradox of plenty'. Among others, the results support the existence of the 'paradox of plenty'.

Keywords: Regional Competitiveness, Social Progress, Firm Performance, Data Envelopment Analysis, Performance

Plenary Session

Keynote Speech Address by Professor C. Kao

Topic : A classification of slacks-based efficiency measures in network data envelopment analysis

Host: Shih-Nan Hwang

## **A classification of slacks-based efficiency measures in network data envelopment analysis**

**Chiang Kao**

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The slacks-based measure (SBM) is a data envelopment analysis (DEA) technique that has been widely used in measuring the efficiency of a system treated as a whole unit. When the internal structure of a system is considered, different ways of modeling the intermediate products that link the component divisions based on the production possibility set (PPS) have been proposed. The types of PPSs can be classified as independent, relational, and cooperative, and the efficiency of the system can be measured from the viewpoint of either outside peers or inside managers for different purposes. This paper shows that models corresponding to the independent type do not properly describe the relationships between the divisions, and are not suitable for measuring the efficiency of network systems. Models corresponding to the relational type may cause a waste of the intermediate products in the system, and are not suitable for internal evaluations, while they are more persuasive for external evaluations. Those corresponding to the cooperative type are appropriate for both external and internal evaluations, and are able to obtain comparable results. An example is used to illustrate the characteristics of the efficiencies measured from the models corresponding to different types of PPSs.

## 4 Full Abstracts

### Session 1A

- **On omplexity of nonparametric efficiency analytics in stochastic environments**  
Kun Chen & Joe Zhu
- **Nash equilibrium in data envelopment analysis**  
Chia-Yen Lee
- **Flexible measures with different returns to scale**  
Mehdi Toloo & Esmaeil Keshavarz
- **Estimating productivity change in a stochastic non-parametric distance function approach**  
Yu Zhao & Hiroshi Morita

## **On complexity of nonparametric efficiency analytics in stochastic environments**

**Kun Chen**

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**Joe Zhu**

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Nonparametric analytics of measuring efficiency in stochastic environments have been studied extensively because of their merits of being robust in contrast to deterministic methods. Such analytics include chance-constrained Data Envelopment Analysis (DEA), mean-variance DEA and non-DEA approach. Although these nonparametric analytics have been built carefully to model the randomness of inputs and outputs of a decision making unit (DMU), optimization methods for solving them lack a rigorous complexity analysis. In response, we examine the nonlinearity of these stochastic programming models and classify them into conic optimization, quasi-convex optimization and non-convex optimization. Moreover, we extend nonparametric efficiency analytics from Gaussian model to two-moment model to deal with datasets which do not follow Gaussian distribution.

## **Nash Equilibrium in Data Envelopment Analysis**

**Chia-Yen Lee**

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Due to the trends of market structure, carbon emission, partial deregulation, each player or decision-making unit (DMU) would like to maximize its individual profit in an imperfectly competitive market. However, a typical data envelopment analysis (DEA) implicitly assuming a perfectly competitive market with exogenous price may violate the practical assumptions, in particular, energy market. Nash equilibrium plays an important role to address these issues and empower the framework of DEA. This study reviews the recent advanced research about Nash equilibrium in DEA, which formulated the profit maximization problem with undesirable outputs and be transformed into the mixed complementarity problem (MiCP) for identifying the Nash equilibrium. Nash solution flourishes the DEA studies such as showing the rational inefficiency, Nash profit efficiency estimation, mixed strategy Nash equilibrium, Nash marginal abatement cost estimation, Nash allocation of emission permit (AEP), etc. Several empirical studies of coal-fired power plants have been conducted to validate the proposed Nash models. The results show that the Nash DEA complements typical DEA researches, and provide the managerial insight for driving productivity in an imperfectly competitive markets.

## **Flexible measures with different returns to scale**

**Mehdi Toloo**

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Evaluation measures in data envelopment analysis (DEA) which are the base of the assessment process have been divided into inputs and outputs measures. However, in some real-world problems, there are flexible measures that their role is not clearly known and depending on the circumstances can play either input or output roles. An important assumption that affects the assessment circumstances is returns-to-scale (RTS) technology. The present paper attempts to confront the problem of classifying inputs and outputs in the presence of different RTS assumptions. The main contribution of the study is formulating envelopment and multiplier classifier models with different technologies and orientations. Practically, we provide a case study to illustrate the applicability and efficacy of the formulated models. The results point out that various RTS and orientations may lead to different classifications.

## **Estimating productivity change in a stochastic non-parametric distance function approach**

**Yu Zhao**

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**Hiroshi Morita**

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In this talk, we show that a Malmquist index of productivity growth can be estimated in non-parametric distance functions on the basis of a stochastic frontier approach. Until recently, Malmquist indexes based upon distance functions have generally been estimated using non-parametric deterministic frontier approaches (e.g., DEA) or parametric stochastic frontier approaches (e.g., SFA). In the conventional nonparametric deterministic frontier approaches, any random noise due to omitted variables, data errors, and other sources of noise are assumed away. Since the data of real world is always more or less noisy, we apply a stochastic frontier approach instead of the deterministic frontier approach. On the other hand, the parametric stochastic frontier approaches require flexible functional forms such as translog for estimating distance functions. A major advantage of using distance functions is that such functions provide a characterization of multi-input multi-output production technologies. However, considering that flexible functional forms often violate axioms of production theory, we estimate the distance functions in a non-parametric way by applying the method of convex non-parametric least squares (CNLS). We then describe how to deal with the estimation and decomposition of Malmquist index by using the CNLS estimators. An illustrative empirical application will also be discussed.

**Keywords:** Malmquist index; stochastic non-parametric distance function; convex non-parametric least squares; multi-input multi-output production technology; productivity change.

## Session 1B

- **Frontier construction, DEA and network DEA models for two-stage systems**  
Qian-Ying Jin & Zhong-Bao Zhou & Tian-Tian Ren & Wen-Bin Liu
- **Measuring and evaluating air force effectiveness using data envelopment analysis**  
Erhan Berk
- **Performance evaluation of green supplier selection problem using DEA-intuitionistic fuzzy MCDM method**  
Babak Daneshvar Rouyendegh & Abdullah Yıldızbası

## **Frontier construction, DEA and network DEA models for two-stage systems**

**Qianying Jin**

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**Wenbin Liu**

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Data envelopment analysis (DEA) is a methodology for evaluating the relative efficiencies of peer decision making units (DMUs). Recently DEA models have been extended to examine the efficiency of DMUs with two-stage processes. In this paper, based on the production possibility set of the two-stage process, we investigate the efficient frontier of two-stage systems. Also we study the relationship between traditional DEA and network models.

## **Measuring and Evaluating Air Force effectiveness using Data Envelopment Analysis**

**Erhan BERK**

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The ultimate measure of national power is military capability. One of the most important elements of military capability is undoubtedly the air force of that country. In order to maintain the highest possible level of operational readiness of the air force, fighter squadrons' operational readiness must be conducted well. The main objective of this paper is to develop a model to determine relative efficiency and to test the effectiveness of fighter squadrons. It is structured in a series of systematic steps to ensure the achievement of the research objectives. This research has shown that Data Envelopment Analysis (DEA) models can be produced to measure the effectiveness of fighter squadrons' operational capabilities and to determine how to improve the performance of the operational capacity. The relationship between efficiency score and input/output factor was examined. Using the results obtained, Air Force was evaluated with respect to operational readiness.

**Keywords:** Air Force, Data Envelopment Analysis, Mathematical Modeling

## **Performance evaluation of Green Supplier Selection Problem Using DEA-Intuitionistic Fuzzy MCDM Method**

**Babak Daneshvar Rouyendegh (B. ERDEBILLI)**

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Supply chain management is one of the fundamental functions that enable firms to move forward in the competitive environment. As a result of increasing competition conditions and customer expectations supplier selection problem has also become increasingly important. In addition to the difficulty of supplier selection, increasing environmental awareness and responsibilities brought the problem of choosing green suppliers (GS). In this case study, discusses a decision-making algorithm with hierarchical structure to find performance efficiencies in order to develop the performance evaluation process in GS in Turkey. The offer presents a Data envelopment analysis (DEA) and Intuitionistic fuzzy MCDM to utilize both criteria. The proposed integrated method is an effective method for selecting and performance evaluation the most suitable GS among the alternatives according to the criteria determined by the order of importance and can be applied to similar problems.

**Keywords:** Green Supplier (GS), Multi Criteria Decision Making (MCDM), Intuitionistic Fuzzy MCDM (IFMCDM), Data envelopment analysis (DEA)

## Session 1C

- **Efficiency measurement with products and partially desirably co-products**  
Wang-Hong Li & Wade D. Cook
- **The performance evaluation of the family farms by using DEA integrated with Orthogonal layout experiment under different combination of inputs and outputs**  
Qian-Wei Zhuang & Yin-Sheng Yang
- **Assessing the efficiency profiles of operating environments in the banking sector: an international study**  
Skarleth Carrales & Jamal Ouenniche
- **Environmental regulatory efficiency and its influencing factors in China: an entropy SBM model with weak disposability**  
Jie-Xin Tang & Qun-Wei Wang
- **A DEA-based decision support reverse auction model for buyer and sellers in electronic procurement**  
Po-Yuan Shih & Dong-Her Shih & Tzu-Shen Huang

## **Efficiency Measurement with Products and Partially Desirably Co-Products**

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Many operational processes that set out to create a specific set of products will often involve the creation of a set of associated co-products. A problem of interest is how to evaluate the efficiencies of a set of comparable such processes in the presence of both products and co-products. In particular, there has been an increasing interest in co-products that can be considered as playing a dual role as either outputs from or inputs to the process involved. Efficiency measurement in certain situations where both products and co-products are present, can be addressed using data envelopment analysis (DEA). For example, reclaimed asphalt coming from the resurfacing of highways in various districts, offers an opportunity to perform maintenance at a lower cost, when that reclaimed material serves as an input together with new or virgin materials. At the same time, there is an undesirable environmental impact when reclaimed asphalt (not reused) serves as an output. In the current paper we develop a DEA-based methodology to evaluate the efficiency of maintenance activities in the presence of both products and co-products. The problem concerns how to examine co-products that can have positive value, up to a certain point, but beyond this point there are disposal/environmental costs that must be considered. We use our developed model to examine the efficiency of resurfacing operations in a set of 18 districts in a Canadian province.

## **The performance evaluation of the family farms by using DEA integrated with Orthogonal layout experiment under different combination of inputs and outputs**

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Data envelopment analysis is a data-oriented non-parametric method for evaluating the relative efficiency of decision-making units. For a group of family farms to be evaluated, most of them have unique characteristics resulting from the owners' management experience, the soil's fertility degree, and some other natural and social factors that would influence agricultural production. Thus, if we choose only one set of indicators while ignoring other indicator combinations to evaluate the family farms' performance in DEA, some strengths or weaknesses of certain family farms might be obscured. Also, the selection of inputs and outputs is not always objective, which will influence the DMUs' score and their ranking. Moreover, it may result in inappropriate proposing strategies. In order to avoid the problems above, we integrated Orthogonal layout experiment which is a statistical approach and DEA method, considering specific information collected from interviewing and questionnaire survey, which are designed specially, of 21 owners of family farms in Jilin Province of China. Orthogonal layout experiment is used for the selection of inputs and outputs integrated with other statistical approaches. We also established a bench-marking unit for evaluation. Finally, we proposed strategies for managing improvement after analyzing the field survey information and DEA performance scores under different combinations of inputs and outputs in this paper.

## **Assessing the Efficiency Profiles of Operating Environments in The Banking Sector: An International Study**

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Several DEA studies investigated the efficiency of banks using static, dynamic, network, and dynamic-network DEA frameworks with and without environmental variables. To the best of our knowledge, no attempt has been made to investigate the relative efficiency of the banking operating environment. This paper aims at filling this gap by analysing the efficiency of HSBC in different operating environments or countries over time using a dynamic-network DEA framework. The choice of a single bank; namely, HSBC, is motivated by isolating the operating environment effect on efficiency and thus avoiding any bias that would result from the relative efficiency of different banks within the same operating environment. Our findings suggest that some banking operating environments should be improved to incentivize more bankers to consider investing in the corresponding countries, which would improve the economy as a whole, on one hand, and competition and financial services / loan offerings, on the other hand.

Keywords: Dynamic-Network DEA, Banking, Operating Environment, Cross-country Analysis

## **Environmental regulatory efficiency and its influencing factors in China: An entropy SBM model with weak disposability**

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To track the relationship between environmental protection inputs and output efficacy, this paper first constructs an environmental regulatory efficiency (ERE) index system and develops a Data Envelopment Analysis (DEA) model suitable for measuring environmental regulatory efficiency. This model not only considers the entropic allocation of multiple inputs, desirable and undesirable outputs, but also integrates undesirable outputs with weak disposability into the model and uses the combined model to calculate ERE during 2004-2014. The influencing factors of ERE were then explored by the panel Tobit model. Results have illustrated that in general, ERE is relatively low in China, with significant geographical discrepancies. In the order of decreasing ERE, it has been shown that the east has the highest values, followed by the west, then central regions, and lastly, with the lowest values, the northeast. Over time, the country experienced decreasing numbers of effective provinces, with the value of ERE inefficiency gradually increasing. Furthermore, it has been discovered that the size of the economy and population density both affected ERE positively, where innovation capabilities exerted a reverse effect, public opinion regarding environmental protection is closely related to the environmental quality, public complaints have reflected the level of undesirable outputs, and this also has an effect of restricting ERE. From the perspectives of industry structure, the level of openness to the outside world, and urbanization, all three displayed no correlation with ERE. The conclusions may be helpful for the regional government to improve ERE.

## **A DEA-Based Decision Support Reverse Auction Model for Buyer and Sellers in Electronic Procurement**

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With the rapid development of Internet, online auctions have becoming one of the most popular form of trading on the Internet. In order to compete in global market, many company have to utilize many electronic procurement technologies to transact with known or unknown suppliers. Therefore, there is a need to provide a decision support tool for them that help buyer to evaluate suppliers in procurement. In this study, we have proposed a multi-attribute, multi-round and multi-unit reverse auction mechanism in electronic procurement. We utilize data envelopment analysis method, buyer inexact preference and integer programming in determining winner of suppliers. We construct the DEA decision model by considering both buyer's and sellers' information that optimize their efficiency score. Each seller can revise their bid according to suggested adjustment from our proposed model, and this may create the competitive bidding in the auction environment. Numerical examples of different settings of parameters are evaluated and discussed.

**Keywords:** Multi-attribute, Data envelopment analysis, E-procurement, Multi-round, Reverse auction, Multi-unit, Decision support

## Session 2A

- **A fuzzy  $\alpha$ -Slacks-Based measure of efficiency in data envelopment analysis**  
Qaiser Farooq Dar & Dong-Her Shih & Tirupathi Rao Padi & V. Charles
- **Determining common weights in data envelopment analysis based on weighted distance**  
Ya-Qin Zhu & Yu Yu & Wei-Wei Zhu
- **Replaceable hierarchical network DEA**  
Tzu-Pu Chang

## **A Fuzzy $\alpha$ -Slacks-Based Measure of Efficiency in Data Envelopment Analysis**

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Data envelopment analysis (DEA) is an excellent nonparametric methodology in operations research and management science for measuring the relative performance of a set of entities on the basis of multiple inputs and outputs. The underlying assumption in conventional DEA models is that input and output data are measured with precision (that is, they are crisp). Nevertheless, many real-life problems take place in uncertain environments; hence, they deal with imprecise or ambiguous input and output data. To overcome this limitation, fuzzy set theory has been proposed as a way to quantify imprecise or ambiguous data in DEA models. In the present paper, we explore the use of fuzzy set-theoretic measures in the context of DEA, wherein we utilize three types of fuzzy methods to measure performance: fuzzy BCC, fuzzy SBM, and fuzzy super SBM. In essence, all three models are applied to illustrate the types of solutions that are achievable when the data are imprecise or ambiguous. Our numerical instance shows that the results of the fuzzy SBM have a better discriminatory power when compared to the results of the fuzzy BCC.

**Keywords:** Fuzzy Set, Parametric Linear Programming, Fuzzy Equalities and Inequalities, Data Envelopment Analysis, Uncertainty.

## **Determining common weights in data envelopment analysis based on weighted distance**

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**Abstract:** The conventional common-weights DEA model is calculated by minimizing the total squared difference between the CCR efficiency and that calculated from the common weights of each DMU, and the weight which assigned to the difference of efficiency between each DMU is 1. However, it ignores the "discourse power" of each DMU is different in the system efficiency evaluation process. This paper optimizes the conventional common-weights DEA model, by combining the "discourse power" of different DMUs with the common-weights DEA. Finally we apply it to evaluate the efficiency of 17 forest districts in Taiwan. The research shows that the method proposed in this paper can make the common weights become more reasonable and stable.

**Keywords:** Data envelopment analysis; Common weight; Efficiency evaluation

## **Replaceable Hierarchical Network DEA**

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Hierarchical network denotes an internal structure that a DMU can be divided into several hierarchical sub-units. However, some hierarchical network datasets may present a replaceable feature, meaning that same data can be used to construct two or more kinds of hierarchical structures with different orders. Hence, this paper aims to find out the relationship between different hierarchical structure models and tries to explain the relationship based on mathematical and economic intuitions. Numerical examples using two and three levels hierarchical network are presented. Finally, this paper uses the Chinese industrial data with a three level hierarchy structure to support our consideration.

## Session 2B

- **An efficiency evaluation of cricket players: a data envelopment analysis approach**  
Zahoor ul Haq Bhat & D. Sultana & Showkat Bashir Lone & Qaiser Farooq Dar
- **Estimation and allocation of cost savings from collaborative CO2 abatement in China**  
Wei-Jun He & Yi Yang & Zhao-Hua Wang & Joe Zhu
- **A sequential Malmquist -Luenberger productivity index of dynamic DEA model with network structure**  
Pooja Bansal & Aparna Mehra

## **An Efficiency Evaluation of Cricket Players: A Data Envelopment Analysis Approach**

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This study evaluates the batting efficiency of Indian cricket players who had retired from One Day International (ODI) cricket and had started their career from 1980 onwards by using Data Envelopment Analysis (DEA). Data Envelopment Analysis is one of the nonparametric linear programming approaches for measuring the relative efficiency and productivity of units called decision-making units (DMUs) after considering multiple inputs and multiple outputs. For the present study, the inputs taken into consideration were number of innings and balls faced by the batsmen and outputs being the runs scored, average and strike rate of the batsmen. The results revealed that only few DMUs attained global technical efficiency but most of them were scale efficient. The DEA benchmarking analysis allows identifying strength and weakness of the players which will be beneficial for the coaches and as well as to the team management.

**Keywords:** Data Envelopment Analysis, Decision Making Units, Technical Efficiency, Batsmen, Cricket

## **Estimation and Allocation of Cost Savings from Collaborative CO2 Abatement in China**

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As an increasingly accepted way of relieving global warming, collaborative carbon dioxide (CO<sub>2</sub>) abatement could improve not only emission performance, but also cost-effectiveness of abatement. In this study, we analyze the cost savings and benefits of collaborative abatement in the context of China by using data envelopment analysis (DEA) approach. Specifically, we establish 63 collaborative abatement scenarios by dividing the Mainland China into six main regions, and then estimate the costs savings in each collaboration abatement scenario. Through investigating the gains for each region in various scenarios, the best collaborative partners for each region are suggested from perspectives of benefit maximization. Furthermore, the contribution of each region to collaborative abatement cost saving is also differentiated with the Shapley value approach.

## **A Sequential Malmquist - Luenberger Productivity Index of Dynamic DEA Model with Network Structure**

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This study proposes a dynamic data envelopment analysis (DEA) model involving network structure to assess the environmental productivity magnification of the decision making units (DMUs) applying the directional distance function (DDF) approach. The model assumes the presence of undesirable output features along with negative and non-negative input-output data values. In a network structure, the multiple divisions of a DMU are vertically connected through network links and horizontally connected through the carry over activities. The dynamic Malmquist-Luenberger productivity index (DMLPI) is proposed to analyze the efficiency performance of a DMU over the entire observation period. The proposed model for DMLPI is shown to be feasible while computing the cross period DDFs. In order to capture the shifts in the efficient frontiers induced by random shocks or innovations in technology over a period of time, the study proceeds to propose the dynamic sequential MLPI (DSMLPI). The advantages of DSMLPI over DMLPI are exhibited through illustrative examples.

## Session 2C

- **Efficiency measurement for hierarchical network systems: a case of financial holding companies in Taiwan**  
Chen-Yu Kao & Cheng-Ping Cheng & Manh-Trung Phung
- **Super-efficiency DEA based on directional distance function in the presence of infeasibility: a parameterized approach in outputs**  
Sheng-Chieh Su & Hsuan-Shih Lee
- **Dealing with undesirable outputs in DEA: an aggregation method for a common set of weights**  
Mei Xu & Wei-Wei Zhu & Yu Yu
- **A new cluster analysis for the major international container ports based on the DEA approach**  
Guo-Ya Gan & Hsin-Yun Chang & Hsuan-Shih Lee
- **Ranking DMUs by using interval DEA cross efficiency matrix with prospect theory**  
Yu Yu

## **Super-efficiency DEA based on directional distance function in the presence of infeasibility: a parameterized approach in outputs**

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In 2013 OMEGA, Chen et al. propose a Super-efficiency model based on a directional distance function (DDF). Their model avoids the infeasibility when zero data occurs in inputs and also prevents the negative destination of the directional scaling under variable returns to scale (VRS). However, their model does not fully eliminate the infeasibility issue when zero data occurs in outputs. Beside, their model relies on complex predetermined parameters. Lin and Chen (2015) propose a new model which prevents infeasibility and negative destination of the directional scaling. The drawback of Lin and Chen's method introduces a constant which would dominate the input of the evaluated DMU. To overcome the drawbacks of Chen et al. (2013) and Lin and Chen (2015), we will develop a new DDF measure for modeling super-efficiency when zero data occurs both in input and output under VRS, and this model will work as ordinary DDF super-efficiency model when all data are positive.

Keywords: DEA, Directional distance function, infeasibility, Super-efficiency

## **Dealing with undesirable outputs in DEA: An aggregation method for a common set of weights**

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The existing approaches that deal with undesirable outputs tend to either increase the efficiency scores of DMUs or keep the efficiency scores constant and do not allow undesirable outputs to achieve the opposite effect on the efficiency scores, which is inconsistent with the characteristics of undesirable outputs. To solve this problem, You and Yan (2011) proposed a new ratio model to allocate penalty coefficients for the undesirable outputs according to their economic costs, but there are differences of magnitude and dimension in various undesirable outputs under practical application. Therefore, this study uses common weights to obtain the aggregate weights of undesirable outputs instead of the penalty coefficients in the original method. We propose two new models to calculate the aggregate weights of undesirable outputs and illustrate the methods by using data on China's textile industry given by You and Yan (2011).

**Keywords:** Data Envelopment Analysis; undesirable output; common weights; efficiency

## **A new cluster analysis for the major international container ports based on the DEA approach**

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Research on the efficiency of world's major international container ports has always been one of the hot issues in the container port market. With the progress of society, the pattern of the world container market is constantly changing. Our study aims at evaluating the changes in top 20 container ports in the new era of the world's shipping market. This study obtains the research data from the Containerization International Yearbook, and combines the concept of 'self-appraisal' and 'peer-appraisal' to construct a quadrant for clustering international container ports into four different types. Our study exposes that the world's container market is showing a good development momentum. However, some container ports also exist in the situations of resources wasting. According to the demands of each port, this study provides some corresponding recommendations with which the operators can adjust their operating strategies.

## **Ranking DMUs by using interval DEA cross efficiency matrix with prospect theory**

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The traditional data envelopment analysis (DEA) model can evaluate the relative efficiencies of a set of decision making units (DMUs) with exact values of inputs and outputs, but it cannot handle imprecise data. Imprecise data, for example, can be expressed in the form of the interval data or mixtures of interval data and ordinal data. The current study aims to propose an alternative strategy, which considers the attitude of the decision maker toward gain and loss. By using the prospect theory, all DMUs in the interval cross efficiency matrix (CEM) could be fully ranked according to the prospect value. Two examples are presented to illustrate and validate the proposed method.

### Session 3A

- **Financial Deregulation and Efficiency of Indian Banking Industry**  
Mohammad Shahid Zaman & Anup Kumar Bhandari
- **Evaluating performance of NBA teams: an alternative double non-homogeneous DEA approach**  
Yu-Qi Wei & Min Yang & Wan-Ting Hu & Jing-Jing Ding
- **Source of growth analysis at industry-level for selected Asian economies using DEA malmquist and Asia KLEMS data bases**  
Hao-Tsung Chen & Tsu-Tan Fu
- **A Study on the Efficiency of Cruise ports in China**  
Shu-Ruei Jhang & Qian-feng Wang & Hsuan-Shih Lee
- **Bootstrapped malmquist indices of Taiwan's international tourist hotels**  
Jin-Quan Tang & Hsiao-Fen Hsiao & Yang Li

## **Financial Deregulation and Efficiency of Indian Banking Industry**

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The banking sector in both developing and developed countries has undergone a significant transformation since early 1980s as large number of countries have liberalised their financial sectors in order to increase efficiency. Financial liberalisation process in India was initiated in 1991-92 with an aim of creating more diversified, profitable and efficient banking system, based on the recommendations of committee on financial sector reforms (Narasimham Committee I, GoI 1991). The underlying philosophy behind financial deregulation was to make banking system more market oriented so as to increase competition in the banking industry. Although in theory, financial liberalisation is expected to improve bank efficiency, empirical results have been mixed (Berger and Humphrey, 1997). This study aims to measure and explain measured variation in the performance of Indian commercial banks during 1996- 2015 using nonparametric Data Envelopment Analysis (DEA). Indian banking industry is an interesting case to study, because of its diversity in ownership. On the basis of ownership commercial banks have been classified into three types – public sector banks or state owned banks, domestic private banks and foreign banks. Although these three groups of banks operate in the same market, each group of banks face a different set of regulations. Two different approaches viz., production approach and intermediation approach have been employed to see how efficiency scores vary with change in inputs and outputs. The analysis seeks to explain variation in calculated efficiency scores to set of bank specific variables like bank size, ownership and capital adequacy ratio. The result shows a positive impact of bank size as well as capital adequacy ratio on bank performance. Also, a significant variation in efficiency scores have been found across different bank ownerships.

## **Evaluating performance of NBA teams: an alternative double non-homogeneous DEA approach**

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Recently, many researchers have studied the evaluation of the performance of National Basketball Association (NBA) teams based on DEA (Data Envelopment Analysis). One prominent issue with these applications of DEA is that both players as an input and wins in Playoffs as an output are non-homogeneous, which we dub double non-homogeneity issue. In this paper, an alternative double non-homogeneous DEA approach is proposed to conduct the performance evaluation of NBA teams and their efficiency decomposition. Furthermore, the conditions for the efficiency decomposition to be unique are discussed; both the overall efficiency and its decomposition efficiencies of each team in the proposed approach are conditionally proved to be unique. Finally, the approach is applied to the NBA data of the season 2016-2017. Results shows that the best performance team is Rockets but not the champion, Warriors, and all teams' efficiencies are not significantly correlated the number of stars. The detailed directions for improvement for all teams including Rockets are provided.

## **Source of Growth Analysis at industry-level for selected Asian Economies using DEA Malmquist and Asia KLEMS data bases**

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The industry-level source of growth analysis using the KLEMS data base has recently been widely adopted for cross-country productivity comparisons. While these studies adopt the growth accounting methods, they fail to decompose the total factor productivity into the components of technical change and efficiency change, which may cause unreliable estimates of productivity and thus mislead the policy implication. The purpose of this research is to integrate panel data production frontier models (DEA Malmquist) with the Asia KLEMS data base for measuring source of output growth and productivity components in Asian economies such as Taiwan, Korea, and Japan. We also identify the major drivers of output growth for each industry of each country investigated and for each time period in 1980-2012. Cross-country comparisons on industrial structure and growth pattern for manufacturing and service industries, as well as results of source of growth and productivity change analysis, are undertaken in this research. This is an innovative research which attempts to integrate the KLEMS data with production frontier models. Therefore, research results will provide important and useful value and references to policy makers.

Keywords: KLEMS, Production frontier, source of growth, DEA Malmquist

## **A Study on the Efficiency of Cruise ports in China**

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At present, the development of cruise industry is rapid in Asia-Pacific. Especially, China is undergoing rapid growth in term of both cruise ship visits and cruise tourists. Although this industry has evolved considerably, the researches in this topic are limited. As a result, we used data envelopment analysis (DEA) on primary data of cruise ports in China and selected output oriented CCR and BCC model to estimate the efficiency of these ports. By comparing with these cruise ports in China, we can find the benchmark of cruise ports. And how do those inefficient cruise ports can be improved.

Keywords: Cruise, Data analysis

## **Bootstrapped Malmquist Indices of Taiwan's International Tourist Hotels**

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Benefited from the expansion of international tourist market, Taiwan's international tourist hotels (ITHs) have expanded rapidly with the support of government policies and aid. Given the simultaneous and perishable nature of hotel service, managing demand from customers and service capacity influences the profitability of ITHs notably. Hence, how to appropriately evaluate the service performance of ITHs attracts the attention of scholars and governments.

The Malmquist productivity index (MPI), proposed by Fare et al. (1994) and based on the data envelopment analysis (DEA), is commonly used to measure total factor productivity (TFP). The primary problem is that being a linear-programming-based measure and lack of statistical nature, MPI may give incomplete information about TFP and its components and thus, guides incorrect policy and/or managerial implications. Hence, this study uses the bootstrapping approach, proposed by Simar and Wilson (1999) which takes into account the time-dependence structure of the data, to generate the appropriate bootstrap samples for analyzing productivity changes of Taiwan's ITHs.

**Keywords:** International tourist hotel, Malmquist indices, bootstrap

### **Session 3B**

- **Efficiency analysis of air pollution and hotel industry of China**  
Yang Li & Xiao-Ying Guo & Wei Wei
- **Advanced network DEA model for measuring the efficiency of Chinese commercial banks with bad loan**  
Zhi-Xiang Zhou
- **Resource Allocation with Consideration of Fairness Based on Efficiency Analysis**  
Tao Du & Lun Ran & Jin-Lin Li & Ran Zhang

## Efficiency Analysis of Air Pollution and Hotel Industry of China

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Environmental quality is not only a prevailing factor in determining competitiveness of tourist destinations, but also a crucial issue in the travel decision-making process (Gani & Clements, 2016; Hu & Wall, 2005; Law & Cheung, 2007; Mihalič, 2000; Zhang, Gu, Gu, & Zhang, 2011; Zhang, Zhong, Xu, Wang, & Dang, 2015). A pleasant environment in tourism destinations can enhance tourism experiences. On the contrary, travelling in a polluted environment would diminish quality of visitor experiences, and consequently decrease their willingness to revisit and recommend the destination. Recent studies (Gani & Clements, 2016; Sajjad et al., 2014; Zhang et al., 2015) suggest that air quality in the tourism destination becomes increasingly important in the travel decision-making process. Although air pollution has become a significant environmental problem in China, up to now, there is little quantitative research on evaluating the impacts of air pollution on China's hotel industry. To fill the gap in the literature, this paper has quantitatively evaluated the impact of air pollution on China's hotel industry. Many studies have used the two-stage approach to analyze how environmental variables influence operating efficiencies, by employing data envelopment analysis (DEA) to obtain efficiency scores in the first stage and then regressing the efficiency scores on environmental variables in the second stage. Most of them have specified the tobit model in the second stage by observing that several efficiencies are equal to unity, suggesting a probability mass at one and a concept of latent variables. Simar and Wilson (2007) argued that it is primarily an artifact of the finite samples of the DEA model to decide whether efficiency equals one and not the property of latent variables. Hence, the appropriate approach in the second stage should be the truncated regression model. In addition, the dependent variable, estimated by the DEA model, is serially correlated, and the random disturbance in the second stage is also correlated with environmental variables. They therefore introduced bootstrap procedures to overcome the above problems. Hence, this study uses the bootstrapped truncated regression model, proposed by Simar and Wilson (2007), to analyze how air pollution influence the efficiency of the China's hotel industry.

Keywords: DEA, China, tourist hotels, air pollution, bootstrapped truncated regression

## **Advanced network DEA model for measuring the efficiency of Chinese commercial banks with bad loan**

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As China's economic development has entered a new normal, Chinese commercial banks have moved more attention to improve efficiency rather than scale. A lot of studies based on data envelopment analysis (DEA) have been done to measure the efficiency of Chinese commercial banks, in which bad loan is usually considered as a pure undesirable output. However, bad loan should be reconsidered in a long time series, a part of the bad loan in the present year should be transferred to income in the coming years. The present paper constructs a set of network DEA models for measuring the efficiency of Chinese commercial banks with considering the positive impact of bad loan in a multiple-years structure. Finally, we intend to apply the new presented paper to Chinese major commercial banks.

## **Resource Allocation with Consideration of Fairness Based on Efficiency Analysis**

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Under the background of increasing national investment in healthcare, how to utilize existing resources to increase the total supply of healthcare service is one of the key issues facing our country at this stage. We constructs a resource allocation model considering equity based on efficiency and proves that the model has Pareto efficient solution. At the same time, due to the deviation of resource allocation in the objective function, it can effectively avoid the multi-solution problem of the model when only considering the output without considering input in the objective function. We use the constructed model to allocate the resources of our country in 2016, we can find that the total output value of health care increased by 28.4402 billion yuan, the number of medical treatment increased by 1.433119941 billion, increasing proportion respectively is 0.86% and 18.07%.

### Session 3C

- **Research on the efficiency of China's open-end fund - based on a two-stage Network DEA model**  
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- **DEA a tool to predict bankruptcy**  
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Yu-Feng Chen & Xian-Hua Wu & Peng Zhao & Ji Guo

## **Research on the Efficiency of China's Open-end Fund - Based on a Two-stage Network DEA Model**

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Data envelopment analysis (DEA) is a method that evaluates the relative efficiency of the decision making units (DMUs). In recent years, network DEA method has been widely used to study the efficiency of complex production structures. The efficiency of fund, which is an important way of investment, has been paid more and more attention. Also, it is a hot topic to study the efficiency of fund with the DEA method.

In this paper, we treat the fund business as a series network structure of two stages, and established a two stage network DEA model with intermediate variables based on the actual situation. The first stage is the operation and management stage, and the second stage is portfolio management stage. We choose 141 open-end fund of year 2016 as the research object from the Wind financial information database, and the inputs of the first stage are management fees, trustee fees and service fees, and the outputs of the first stage which are also the inputs of the second stage are net assets value and the fund size, and the outputs of the second stage are return rate and alpha (which is the excess return rate). According to the fund size, we divide them into three groups, and obtain the efficiency value and ranking of the whole and each group respectively. We combine the evaluation results and some basic situation of the fund to analyze the following aspects. First of all, we compare the overall efficiency values, the sub-stage efficiency values and rankings of the funds, and analyze the different performance of the funds in two stages. Secondly, we find that the efficiency situation of small sized funds is better than large sized funds by comparing the ranking of all funds. Finally, we analyze the significance and realistic meaning of the efficiency results according to other indicators of funds by using TOBIT model, such as the investment concentration, team stability and Wind comprehensive rating. One important conclusion is that the longer the establishment year of the fund is, the better the efficiency value of the fund is.

**Keywords:** Data Envelopment Analysis; Two-stage DEA Model; Open-end Fund; Fund Efficiency

## **DEA a tool to predict Bankruptcy**

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Bankruptcy is a popular topic of research given the significant financial, economic and personal consequences it can have on many parties, including employees, customers, creditors, suppliers, and business owners. Being able to predict bankruptcies would permit more sound investment decisions from investors, better risk assessment from creditors, and improvements to overall economic and societal conditions. If accurate predictions could be made sufficiently in advance, remedial actions to prevent the failure could potentially be taken. While the most prevalent bankruptcy prediction models, such as the Altman Z-score, rely on financial ratios, efficiency measurement techniques are natural choices to employ for bankruptcy prediction because of the intuitive assumption that inefficient firms would be more likely to fail.

In particular, many studies have employed Data Envelopment Analysis (DEA) to predict bankruptcies. This study considered multiple methods of applying DEA to bankruptcy prediction, including classification via cutoff score thresholds or layering, and combinations of various models in two-stage models. A novel means of employing DEA layering was also developed. Most existing bankruptcy prediction methodologies only consider financial data. The work described herein also examined whether including managerial, market and economic factors would improve the efficacy of the predictions. Most techniques only provide dichotomous predictions (i.e. survive or fail). In contrast, a method to determine likelihood of bankruptcy from DEA model results was developed. Furthermore, by employing the benchmark identification inherent in DEA, strategies to improve operations of failing firms can be identified to attempt to mitigate or prevent bankruptcies.

The developed models were applied to a case study of the US retail-apparel industry. It was found that amongst the additional non-financial data considered in the models, only managerial decision making outcomes were helpful in explaining bankruptcy in this industry. The prediction results from the newly developed layering method compared favorably with the Altman non-manufacturing Z-score. Also, polynomials fitted to the new layering scores were found to model the probability of bankruptcy well in the case study.

## **A data envelopment analysis application in performance appraisal for project human resource management: A case study in IC design company**

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Many companies attempt to quantify the employee performance, but find it extremely difficult to select an appropriate performance appraisal (PA) methodology for human resource management to assess employee performance by some indicators. Therefore, this study uses Data Envelopment Analysis (DEA) as an evaluation tool and discusses the practical application and management implications of this method. According to the literatures and relevant practical experience, the input variables are hours of work, the duration of tasks, and length of service; the output variables are organizational commitment, job satisfaction, and the amount of outputs. The case company is a leading Taiwanese IC design company, and fifteen employees who are responsible for the same job were invited to participate in this study.

This study indicates that DEA method provides four main functions in employee performance appraisal: (1) Managers are able to choose the inputs and outputs in the DEA model based on practical needs; (2) Besides the overall technical efficiency, the DEA model also indicates pure technical efficiency and scale efficiency, thereby providing the direction for improvement; (3) To provide different target values and improvement ratios to each DMU so that employees could have their own goals; (4) Managers are able to understand each employee's position based on BCG matrix, and each DMU could identify the peers by "reference groups", and furthermore, managers could make use of teamwork to help the employees with lower efficiency.

## **Regional industrial efficiency analysis of China: An interval Enhanced Russell Measure approach with undesirable outputs**

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Traditional data envelopment analysis only measures efficiency from single orient, whereas, Enhanced Russell Measure is able to evaluate performance from input and output orient simultaneity. The deficiency of current Enhanced Russell Measure is lack of consideration of uncertainty information and undesirable outputs. This paper, we come up with a new model based on Enhanced Russell Measure model with interval data in the presence of undesirable outputs. Further, we provide a novel approach based on possibility degree for ranking of interval efficiency. This method is applied to analyze regional industrial efficiency in china, it interprets that regions in eastern of china are almost all ERM efficient, excess undesirable emission of waste gas, waste water and waste solid give rise to unsatisfying efficiency of central and western regions.

## **Study of haze emission efficiency based on new co-opetition DEA**

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As haze intensifies in China, controlling haze emission has become a top priority in the country's environment protection endeavor. Yet a reasonable evaluation of the emission efficiency of haze is the premise and basis to control haze emissions. Since haze moves across different regions, it's necessary to develop a DEA (Data Envelopment Analysis) model underpinned by both competition and cooperation to evaluate the haze emission efficiency in different provinces. This study innovatively adopts the spatial econometrics to construct the co-opetition matrices of Chinese provinces, then builds the co-opetition DEA model that evaluates the haze emission efficiency of them, and finally uses the haze data for 2015 as an example to assess the applicability of the model. The results of the study include: (1) The haze emission efficiency of provinces, resulting from the evaluation based on the co-opetition DEA method, varies greatly: those with high efficiency are mostly inland provinces that have a slow-growing economy and bad climatic conditions, while many of the provinces that have low efficiency are located in the relatively prosperous east China; (2) Compared with the efficiency value gained using the CCR model, the haze emission efficiency values for Tianjin and Guangdong, two decision-making units, register greater variance when using the DEA model. The reason might lie in that they have a different spatial transportation relationship with their surrounding provinces; (3) Compared with the traditional CCR model, this study constructs the co-opetition DEA cross-efficiency model that integrates haze's feature of cross-border moving, and is thus more in line with the reality of haze emission and movement. The specific co-opetition DEA model constructed in this study enriches the research on the DEA model, which can be applied to the emission efficiency evaluation of similar pollutants that cross border and can contribute

empirical support to the haze reducing efforts of the government with its empirical results.

## Session 4A

- **A malmquist productivity index for assessing photovoltaic program in Belgium**  
Adel Hatamimarbini & Seyed Mojtaba Sajadi & Mona Alibeik
- **Does firm performance matter while going public? Evidence from India**  
Vipin Valiyattoor & Mohammad Shahid Zaman & Sabuj Kumar Mandal
- **Three-stages network data envelopment analysis: an application to equity mutual funds in Taiwan**  
Chia-Jui Li & Manh-Trung Phung & Cheng-Ping Cheng
- **Efficiency of Indian public sector banks in presence of undesirable output: An application of directional distance function approach**  
Sunil Kumar

## **A Malmquist Productivity Index for Assessing Photovoltaic program in Belgium**

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In recent years, solar energy from rooftop photovoltaic (PV) systems has significantly contributed to renewable energy in European Union (EU). On the other hand, the Belgian policy makers have lately decided to phase out nuclear power by 2025 because the ageing reactors of Tihange and Doel plants has brought the safety concerns on by Germany, the Netherlands and some Belgian citizens. Therefore, the investment and planning for PV systems in Belgium play a crucial role as a green way to make a smooth transition to this radical change in electricity generation. This study makes an attempt to apply the Malmquist productivity index to measure and decompose green productivity growth for 262 municipalities in the Wallonia region of Belgium. We take the environmental and socio-demographic factors into account and we classify the municipalities into 'green' and 'yellow' groups. The analysis also identifies the determinants of green productivity growth and delivers some useful policy implications.

## **Does firm performance matter while going public? Evidence from India**

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This study makes an attempt to investigate the impact of firm performance, measured by technical efficiency as well as accounting measure of performance on going public decision of Indian firms by undertaking Initial public offerings (IPO) for the period 2006-2014. We use an unbalanced panel data of 2147 companies to estimate technical efficiency of firms using Data Envelopment Analysis (DEA) and adopt Panel probit model to estimate the nexus between firm performance and going public decision. Our results show that the probability of going public decreases with increase in firm performance. At the same time, older firms are more probable of going public and we find a positive relationship between leverage and probability of going public.

## **Three-Stages Network Data Envelopment Analysis: An Application to Equity Mutual Funds in Taiwan**

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Mutual fund is one of the most important investment channel in the modern financial market. Measuring its performance, hence, has been arising as an interesting topic for many researchers. The traditional approach utilizes some financial indexes such as Sharp, or Treynor ratios. Such approach, according to the perspective of production management, is infeasible in exploring the performance of internal process. Another approach - network data envelopment analysis (NDEA) appears to be more favorable to solve this problem. However, there is still lack of literature regarding efficiency decomposition of mutual fund. This paper extends the three-stage NDEA proposed by Galagedera et al. (2017) to evaluating the relative efficiency of 143 equity mutual funds in Taiwan in 2017. The overall efficiency is decomposed into three divisional efficiencies: operational management, resource management and portfolio management. Furthermore, environmental conditions - levels of risk exposure are also discussed. The empirical results indicate that our model are better in discriminating power.

Keywords: Mutual fund management; Network data envelopment analysis; Efficiency decomposition

## **Efficiency of Indian public sector banks in presence of undesirable output: An application of directional distance function approach**

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The main objective of the present work is to provide an analysis of efficiency of Indian public sector banks considering non-performing loans as an undesirable output. In carrying out the empirical analysis, we apply the sequential DEA based directional distance function methodological framework. The directional distance function used for obtaining efficiency scores is non-oriented once which allows the reduction in inputs and undesirable output, and expansion of desirable outputs simultaneously. In this model we incorporate equity capital as a non-controllable input along with variable inputs. The bank output vector consists of two desirable outputs: advances ( $y_1$ ) and investment ( $y_2$ ) and one undesirable output: non-performing loans ( $b$ ). We assumed that bank uses three variable inputs: labor ( $x_1$ ), fixed assets ( $x_2$ ) and loanable funds ( $x_3$ ), and one non-controllable (quasi-fixed) input: equity capital. The equity capital is incorporated to control for the risk-return trade off faced by the banks. The empirical results pertaining to the study period spanning from 1999 to 2017 highlights that there exists substantial efficiency differences across banks. The results also highlight the presence of convergence in the efficiency levels.

Keywords: Technical efficiency; Nonperforming loans; Indian banks; Directional Distance Function;; convergence analysis

## Session 4B

- **Measuring efficiency changes in two-stage with feedback production systems by data envelopment analysis**  
Xian-Mei Wang & Han-Hui Hu & Cheng-Yang Xie
- **Benchmarking water sector performance of Indian states using multidimensional Water Poverty Index**  
Ashish Chopra & Parthasarathy Ramachandran
- **Centralized fixed cost allocation for generalized two-stage network DEA**  
Tao Ding & Hua-Qing Wu & Liang Liang

## **Measuring efficiency changes in two-stage with feedback production systems by data envelopment analysis**

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The existing multi-period two-stage data envelopment analysis (DEA) model is extended from conventional DEA to explore the internal structure of network production systems and the performance changes in a specified period, where the relationships among the (previous) outputs and the (current) inputs in different periods are not examined. In the development of service industry, such as the previous high user access level can promote the follow-up performance due to the positive user externalities. This paper takes the feedback setting among adjacent periods into account to develop an advanced relational model, and discusses the relationships between the system efficiency and the division efficiency through aggregation and decomposition. Based on these relationships, the sources of inefficiency in a given time or period of any DMU can be discerned and the specific improvement approaches can be proposed in the future. The cable TV industry in China is used to illustrate this model, and to uncover the reason why some provinces have poor performance in certain time.

## **Benchmarking water sector performance of Indian states using multidimensional Water Poverty Index**

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Water as a basic natural resource plays a very important role in the economic, ecological and human development of any country. Water in India is a state subject and the provision of a reliable, safe and sustainable supply of water has emerged as a challenge due to geographical and institutional constraints of water resources. In this study, we seek to understand the challenges faced by different states in India in administering the water resources of the state.

Other than physical availability, the financial and institutional limitation also leads to poor performance of water sector in India. For integrated assessment of water sector, a multidimensional index i.e. water poverty index (WPI) has been used worldwide at different scales. Benchmarking of water sector performance will help the policy makers to understand and prioritize the areas of improvement in the water sector.

The objective of this study is to calculate the WPI, consisting of five dimensions namely Resources, Access, Capacity, Use, and Environment. This will capture not only the physical but also other socio-economic and ecological aspects of water sector performance for different states in India. In earlier studies, different methods such as equal weights, Delphi method etc. have been used to aggregate these five components. In this study, Data Envelopment Analysis (DEA) will be used to calculate the aggregated index such that it maximizes the overall water sector performance of a given state.

## Centralized fixed cost allocation for generalized two-stage network DEA

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Many studies have dealt with fixed cost allocation problem by using data envelopment analysis (DEA). However, existing models allocate the fixed cost by treating the DMUs as black-boxes while the internal production structures of DMUs are ignored. To our knowledge, only Yu et al. (2016) consider the fixed cost allocation problem for an elementary two-stage production structure without external inputs and outputs. This paper deals with the fixed cost allocation problem for a general two-stage network production structure, in which both external inputs and outputs exist. Specifically, additive two-stage models are firstly presented to evaluate the performance for each DMU with the allocated cost. Then, by introducing the concepts of satisfaction degree and fairness degree, we proposed an approach to obtain an optimal allocation plan under the control of the centralized authority. Finally, an application to 27 banks is utilized to illustrate the proposed approach.

## Session 4C

- **Super-efficiency DEA based on directional distance function in the presence of infeasibility: a parameterized approach in inputs**  
Yan-Yu Chen & Hsuan-Shih Lee
- **Evaluating Performance of the Restaurant Companies: Application of the Meta-frontier Approach**  
Chia-Ning Chiu
- **Analyses of demand characteristics based on a novel nonparametric method with an application to Huangshan short-term apartments sharing data**  
Dan Hu & Chen-Peng Feng & Jing-Jing Ding & Min Yang
- **基於偏好排序的江蘇省創新指數評價方法研究**  
朱衛未 & 朱亞琴 & 于娛
- **基於逆 DEA 方法的中國可持續發展投資分析**  
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## **Super-efficiency DEA based on directional distance function in the presence of infeasibility: a parameterized approach in inputs**

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According to Ray (2008) introduces the VRS Nerlove-Luenberger (N-L) super-efficiency model. Their model fails under two situations. First, when zero data occurs in inputs. Second, it prevents the negative destination of the directional scaling. In 2013, Chen et al. propose a super-efficiency model based on directional distance function that avoided two cases. But, their model relies on complex predetermined parameters and might be infeasible when zero data occurs in outputs. Besides, Lin and Chen (2014) propose a new model which prevents infeasibility and negative destination of the directional scaling. Lin and Chen's method introduces a constant which would dominate the input of the evaluated DMU. However, to overcome the drawbacks of the models proposed by Chen et al. and Lin and Chen, we will develop a new super-efficiency model based on directional distance function(DDF), which prevents infeasibility when zero data occurs and working the same as original super-efficiency based on DDF when all data are positive.

Keywords: DEA, Directional distance function(DDF), infeasibility, Super-efficiency

## **Evaluating Performance of the Restaurant Companies: Application of the Meta-frontier Approach**

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According to 2017 States of the Industry report from the National Restaurant Association, there are \$799 billion sales generated from the restaurant industry and over 1 million restaurant locations in the United States. Moreover, there are 14.7 million employees provided from the restaurant industry. National Restaurant Association also predicts that by the year of 2027, there are 1.6 million new restaurant jobs created from this industry. Furthermore, 10% of the overall the United States workforce belongs to the restaurant workforce. Through the statistical figures mentioned above, the restaurant industry plays an important role for the economic development and increasing the rate of employment. Therefore, the purpose of this study is to assist restaurant firms to have a better understanding about which factors can affect their business performance and what business strategies can be adjusted so that restaurant companies can reach profit maximization with minimum costs.

There are many types of restaurants in the United States, including ethnic, fast food, fast casual, casual dining, family style or dining, etc. However, this study roughly classifies the 20 listed restaurant companies into two groups: fast food/ service and non-fast food restaurants. No matter which types of restaurants, they can attract different types of customers with different eating purposes, especially nowadays more and more people dine out at restaurants and then restaurants have become essential parts of life. Also, limited studies focus on efficiency measurements on the restaurant industry. In order to have a better understanding of how to increase technical efficiency from reducing the inputs of different types of restaurants is vital to improve their business performance, this study applies the directional distant function and Battese, Rao, and O'donnell (2004)'s meta-frontier approach in the listed restaurant companies and compares fast food/ service with non-fast food restaurant companies. The efficiency and technology gap ratio (TGR) are computed for the 20 listed restaurant companies from 2009 to 2016 in this study. Based on pervious related research studies, one output (revenues) and four input variables, including assets, salaries, food expenses, and number of employees are collected for computing the efficiency scores and technology gap ratios. The technology gap ratio of fast food restaurants is higher than that of non-fast food restaurants. This indicates that non-fast food restaurants have more room to improve their technical efficiency by reducing the inputs such as eliminating unnecessary expenses, lowering overhead costs, renting equipment rather than purchasing it, etc. The results can contribute to academia and the industry. For academia, this study reviews the theory of production economics and examines the concepts of productivity and efficiency measurement. For the industry, the empirical findings benefit both fast food/ service and non-fast food restaurant companies for their

business model adjustments and marketing strategies' development. Moreover, more implications of the findings are provided in the full paper.

## **Analyses of demand characteristics based on a novel nonparametric method with an application to Huangshan short-term apartments sharing data**

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Recently, the sharing economy is changing the business modes in China. As one of the newest business modes, the sharing economy asks for everyone to be involved; yet it has a typical decentralized nature, which attracts the attention from both industries and academia. This paper attempts to probe into the specific relations of participants in the sharing economy among demand, price and product features by constructing demand possibility set (DPS) based on data envelopment analysis (DEA). Specifically, the proposed method is permitted to analyze the replaceable relationship among demand, price and product features. Furthermore, the proposed model can be applied to support decisions such as product pricing and product recommendation. Short-term apartment sharing is one of the hottest practical fields of sharing economy. This paper chooses Huangshan city as a research setting as it is one of the world famous tourist resorts, and has a prosperous prospect in the sharing apartment market. The proposed DPS-DEA model is applied to analyze the demand characteristics of 40 Huangshan short-term apartments sharing.

## 基于偏好排序的江苏省创新指数评价方法研究

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随着社会的不断发展，创新成为第一生产力。传统的创新指数评价指标体系和方法难以适应新环境下创新发展能力的评价。因此，本文结合江苏省“十二五”规划阶段发展状况，以江苏省创新型城市建设评价考核指标体系为理论基础，构建了江苏省创新指数评价指标体系。运用偏好排序的 DEA 模型，从时间和空间的层面探讨了江苏省创新发展现状。结果表明江苏省创新能力在国内处于领先水平，但是“十二五”规划期间江苏省创新能力并未实现稳定增长，创新指数仍然存在不稳定变化，其中创新产出指数偏低是影响创新能力的关键。

关键词：创新指数，偏好排序，DEA

## 基於逆 DEA 方法的中國可持續發展投資分析

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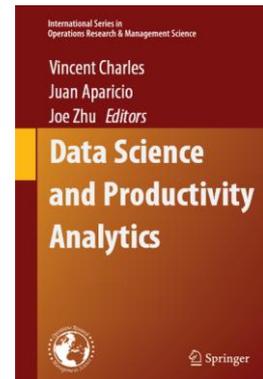
**Yi-Xin LAN 藍以信**

福州大學

為了更好地實現資源的優化配置，本研究構建了考慮非期望要素的逆 DEA 模型，以測算在特定期望產出、非期望產出和效率值的生產情境下 DMU 所需要的最少資源投入量。在此基礎上，結合實際的生產需求，本研究定義了自然、規制和最優三種視角來分析可持續發展的投資問題，並制定相應的投資方案。同時，定義一種理想視角為決策者進一步改進效率指明方向。該方法在 2005-2014 年中國經濟可持續發展相關資料的基礎上對 2015-2024 發展所需的投資量進行預測，並制定適用於不同發展需求的具體投資方案。最後，給出了相關的改進路徑及政策建議。

## 5 Talents Recruiting

Data Science is considered as one of today's most interesting fields of research; a Google search in January 2018 for the string 'data science' with quotation marks returned 24.1 million results, showing an increasing trend over time. Data science is defined as the collection of scientific methods, processes, and systems dedicated to extracting knowledge or insights from data and it develops on concepts from various domains, containing mathematics and statistical methods, operations research, machine learning, computer programming, pattern recognition, and data visualisation, among others. Examples of data science techniques include linear and logistic regressions, decision trees, Naïve Bayesian classifier, principal component analysis, neural networks, predictive modelling, deep learning, text analysis, survival analysis, and so on, all of which allow to use the data to make more intelligent decisions.



On the other hand, it is without a doubt that nowadays the amount of data is exponentially increasing, and analysing large data sets has become a key basis of competition and innovation, underpinning new waves of productivity growth. This book aims to bring a fresh look onto the various ways that data science techniques could unleash value and drive productivity from these mountains of data.

The book aims to bring together a spectrum of concepts, such as performance, productivity, operations research, econometrics, and data science, for the practically and theoretically important areas of 'productivity analysis/data envelopment analysis' and 'data science/big data'. These areas are of widespread interest to researchers and practitioners alike.

We wish to invite you to contribute to this edited book. As such, we invite you to submit an extended abstract to [cio@umh.es](mailto:cio@umh.es) (mentioning in the subject of the email: "Data Science and Productivity Analytics") by **31/July/2018**, clearly indicating the objectives of your proposed chapter, its originality, and methodology employed.

### IMPORTANT DATES

31/Jul/2018	Submission deadline for extended abstract
15/Sep/2018	Communication of decisions from editors
01/Dec/2018	Submission of full chapters
28/Feb/2019	Notification of first round of review results
31/May/2019	Submission of revised chapters
15/Jul/2019	Notification of second round of review results
31/Aug/2019	Final decisions notifications

The expected publication date of the book is **December 2019**.

For further information or clarifications about this Call for Book Chapters, please do not hesitate to contact the Editors directly, via email.

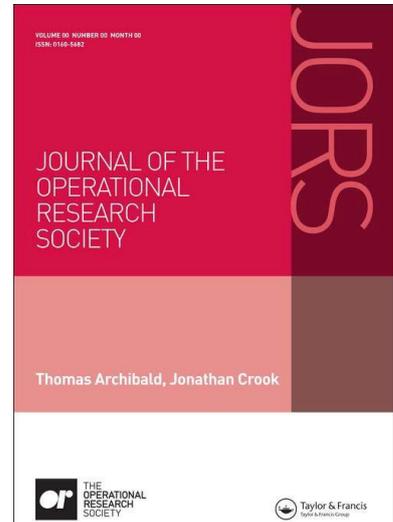
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## Journal of the Operational Research Society Contribute to our special issue on Data Science for Better Productivity

Deadline: 31 October 2018

Today's global competition and rapid development of information technology has led to the creation of massive amounts of data that are, moreover, exponentially increasing day by day.

Analysing these large data sets is a key basis of competition and innovation, and supports new waves of productivity growth. This has challenged organizations to find novel ways to analyse and use the data to make more intelligent decisions and increase their productivity. Data Science, encompassing a collection of scientific methods, processes, and systems, is one of today's most interesting fields of research and allows organizations to extract knowledge or insights from these existent mountains of data. As such, PRODUCTIVITY ANALYSIS/DATA ENVELOPMENT ANALYSIS and DATA SCIENCE/BIG DATA are areas of growing interest to researchers and practitioners alike, with a significant body of research focusing on either of them. It is, nevertheless, not too bold to say studies dedicated to addressing both the fields at the same time are rather scarce.



This Special Issue encourages original research papers of high quality that focus on novel ways of using the existent data science techniques and/or the development of novel data science techniques to improve and/or unleash value and drive productivity from large data sets, and with practical applications in various domains. Empirical research studies, as well as the development of new or modified methodologies to address challenging and emerging issues in DATA SCIENCE/BIG DATA and PRODUCTIVITY ANALYSIS/DATA ENVELOPMENT ANALYSIS, are of considerable interest. Contributions from both the academic and the practitioner communities are encouraged.

TOPICS AND AREAS covered include but are not limited to:

- Performance
- Productivity
- Operations Research
- Econometrics
- Machine Learning
- Data Science
- Data Visualization
- Computer Programming
- Pattern Recognition, and so on.

DATA SCIENCE TECHNIQUES covered include but are not limited to:

- Linear & Logistic Regression
- Mathematical Programming
- Decision Trees
- Bayes Classifiers
- Principal Component Analysis
- Data Envelopment Analysis
- Neural Networks
- Predictive Modelling
- Deep Learning
- Text Analysis
- Survival Analysis, and so on

## Submission instructions

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For further information or clarifications about this Call for Papers, please do not hesitate to contact the Special Issue Editors directly.

The Special Issue is scheduled for publication in December 2019.

Dates for your diary

31/10/2018 - Submission Deadline

28/02/2019 - Notification of first round of review results

30/11/2019 - Final acceptances after second round of review

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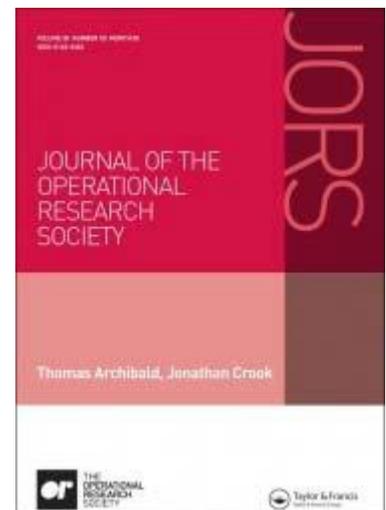
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