Book of Abstracts

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Book of Abstracts

Paper ID: P6
Author(s): Mahnaz Mirbolouki
Title: **Identifying type of right and left returns to scales: Hyperplane approach**

Abstract: This study investigates the identification of right and left returns to scale. The concept of right and left RTS has been considered by some researchers, but all of the introduced models are parametric. Here, an approach based on right and left common hyperplanes is presented and MIP models are proposed. The comparison of computational results shows the weakness of previous methods.

Paper ID: P10
Author(s): Eduardo Gonzalez, Ana Carcaba and Juan Ventura
Title: **Malmquist decomposition of the evolution of QoL in Spanish municipalities (2001-2011)**

Abstract: We use a list of 16 social indicators covering 8 QoL domains in 400 Spanish municipalities in 2001 and 2011 to compute a composite indicator, using weight constrained DEA. These dimensions cover all the relevant aspects of QoL: living conditions, housing, education, health, safety, personal activities and environment. We compute a Malmquist index comparing both periods to track the changes occurred during the decade. The Malmquist index is then decomposed into a catching-up effect and a frontier shift component, showing joint social progress. This allows interpreting the global evolution of QoL for these municipalities and also to assess which of them have moved towards the frontier (catching-up). The results show that the Mediterranean area has been the most affected by negative catching--up, while the central-northern regions still dominate the QoL frontier. The Southern regions show poor QoL scores, but some positive catching-up is observed. Overall there has been advance in QoL conditions as represented by frontier shifts.

Paper ID: P12
Author(s): Joyeeta Deb and Santa Kar
Title: **Efficiency determinants of microfinance institutions in India**

Abstract: Micro finance Institutions provides financial support to the deprived section of the society, who is unable to receive formal banking facilities, and thus is considered an integral part for developing an economy. Talking about India, where till date a large number of population is poor, uneducated, deprived of formal banking services, Micro finance Institutions works as bridge in filling up the gap between the underprivileged population and the formal banking system. Recently the studies on efficiency of Micro finance institutions have received wider attention. Therefore, it is felt relevant to study the efficiency of such institution in Indian context. Besides efficiency, this paper also attempts to identify the determinants of efficiency specifically answer whether 'sustainability' has any significant impact on efficiency. Relevant data are collected through secondary source from thirty-one Indian Micro finance Intuitions and non-parametric data envelopment analysis is used for gauging the efficiency, thereafter, tobit regression is used to identify the determinants of efficiency.

Paper ID: P14
Author(s): Maryam Allahyar, Mehdi Toloo and Jana Hanclova
Title: **A directional distance method on classifying inputs and outputs in DEA**

Abstract: The original data envelopment analysis (DEA) models have required an assumption that the status of all inputs and outputs be known exactly, whilst we may face a case with some flexible performance measures which whose status is unknown. Some studies have been done to deal with flexible measures. This contribution develops a new classifier directional distance method with the aim of taking into account input contraction and output expansion, simultaneously, in the presence of flexible measures. To make the most appropriate decision for flexible measures, we suggest two pessimistic and optimistic approaches from both individual and summative points of view. Finally, a numerical real example is presented to elaborate applicability of the proposed method.

Paper ID: P15
Author(s): Fariba Khalafi and Reza Kazemi Matin
Title: **Efficiency decomposition in network data envelopment analysis with non-radial models**

Abstract: Conventional data envelopment analysis (DEA) treats production systems as a black-box when measuring efficiency, by ignoring internal structures of sub-processes. By taking the operations of the sub-processes into consideration, several network DEA models have been developed. Of these, the non-radial approaches have attracted much attention for their ability to provide suitable efficiency measures, especially for weakly efficient production systems. This paper proposes a Russell measure for general network production systems. It enables decomposing the system efficiency into a weighted average of the sub -process efficiencies. The decomposition of the system efficiency helps identify key factors to improve the performance of any inefficient production unit. An illustrative case is applied to demonstrate that the new general network model has stronger discriminating power than the conventional black-box models.

Paper ID: P18
Author(s): Shiu-Wan Hung, Dong-Sing He, Min-Jhih Cheng and Chen-En Hou
Title: **Is government funding critical to the operation performance of technology universities? A case study of Taiwan**

Abstract: The technology-concentrated manufacturing industry is the foundation of economy, and technology education cultivating technology personnel is, in turn, the foundation of the manufacturing industry. The reason Taiwan is capable of sustaining its development and creating an economic miracle lies in its abundant and high-quality labour force that can generate economic output values. As a result, technological and vocational education is vital. The study used the Malmquist productivity index (MPI) to evaluate the operation performance of technology universities in Taiwan. In addition, the bootstrap method was employed to analyse MPI sensitivity to verify the stability of the index. The results suggested that national technology universities on average showed better efficiency than private technology universities. Technology universities with a greater proportion of total income from government

subsidies did not show better operation performance. Operation performance of technology universities in the study was not significantly affected by whether the school is in the north, central or south Taiwan.

Paper ID: P19
Author(s): Chen-En Hou, Shiu-Wan Hung and Wen-Min Lu
Title: **Does CSR matter? Influence of corporate social responsibility towards corporate performance in the creative industry**

Abstract: The creative industry is one of the fastest developing emerging industries which provide continuous social and business benefits to regional economics by generating creative goods that stimulate the exploitation of human creativity and business activities. Due to the inclusion of social and business benefits, the evaluation of creative industry's business performance under social influences remain a challenge in both academy and practical field. This research explores the relationship between business performance and social influence of the creative industry using a longitudinal perspective. We evaluate the efficiency performance of 53 creative business from 2010-2013 via a dynamic data envelopment analysis, and use business-specific corporate social responsibility data to perform regression analysis. Our results show that corporate social responsibility has positive and significant influence on business performance of the creative industry. Also, result shows that the creative industry have the characteristic of high risk and high reward, and larger creative business scale and lower financial leverage would also benefit the overall performance of the creative industry.

Paper ID: P20
Author(s): Hadi Bagherzadeh Valami
Title: **Introduction a fuzzy efficiency score in Data Envelopment Analysis with fuzzy data**

Abstract: Data envelopment analysis (DEA) is a widely applied approach for measuring the relative efficiencies of a set of decision making units (DMUs), which use multiple inputs to produce multiple outputs. In real world problems the data available may be imprecise. With fuzzy inputs and fuzzy outputs, the optimality conditions for the crisp DEA models need to

be clarified and generalized. The corresponding fuzzy linear programming problem is usually solved using some ranking methods for fuzzy sets. In this paper, we introduce a fuzzy efficiency score and a numerical method for ranking DMUs with fuzzy data.

Paper ID: P21
Author(s): Mohammad Khoveyni and Robabeh Eslami
Title: **Finding the stability region of efficiency of efficient firms for upward variations of inputs and downward variations of outputs**

Abstract: Finding stability region of efficiency for an efficient firm (or generally decision-making unit (DMU)) is one of the important issues from the economic point of view, which the DMU remains efficient within this region. This paper proposes a data envelopment analysis (DEA) approach to find the stability region of efficiency for upward variations of inputs and/or for downward variations of outputs of an (extremely) efficient DMU. Boljučić (2006) [Boljučić, V. (2006). Sensitivity analysis of an efficient DMU in DEA model with variable returns to scale (VRS). Journal of Productivity Analysis, 25 (1-2), 173–192] suggested a DEA approach to identify the stability region of efficiency. As a matter of fact, the complexity of the Boljučić's approach is high, however, the proposed DEA approach has an acceptable complexity. To demonstrate the applicability of the proposed approach in economics, an empirical application to the banking industry in the Czech Republic is provided.

Paper ID: P22
Author(s): Robabeh Eslami and Mohammad Khoveyni
Title: **Estimating returns to scale of two-stage network processes**

Abstract: Network data envelopment analysis (NDEA) deals with evaluating the performance of a set of homogeneous decision-making units (DMUs) taking into account the internal structure of DMUs. A large number of studies in NDEA are based on two-stage structures. In this context, the methodology was offered by Fukuyama and Mirdehghan (2012) [Fukuyama, H., & Mirdehghan, S.M. (2012). Identifying the efficiency status in network DEA. European Journal of Operational Research, 220, 58–92] for Identifying the efficiency status of network

efficient DMUs. The current research with the aim of proposing a DEA approach to determine right-and left-hand RTS (returns to scale) of the identified network efficient DMUs. Finally, a numerical example is provided to illustrate the proposed approach.

Paper ID: P26
Author(s): Kamran Rashidi and Kevin Cullinane
Title: **Sustainable logistics performance: An international case study**

Abstract: The logistics industry helps decision makers to reduce logistics costs through logistics outsourcing and also plays a vital role in the growth of gross domestic product. Thus, logistics performance evaluation at an international level, which has been widely neglected in the literature, needs to be implemented in order to gain valuable information for the countries which are actively operating within this industry. Although international logistics performance evaluation reveals some remarkable information regarding the developing importance of sustainability issues in recent years, it is better to consider triple bottom line concept as part of this evaluation process. Samples of OECD countries are selected as units of analysis. The sustainable logistics performance of these countries is evaluated based on economic, environmental, and social criteria using DEA technique. The results of this paper:* Ranking of the sample countries with respect to sustainable logistics performance. * Disclosing the source of inefficiencies. * Providing a good starting point for each sample country to identify how it needs to improve the performance of its domestic logistics service providers.

Paper ID: P27
Author(s): Younos Vakil Alroaia
Title: **Evaluating the performance of companies listed in Tehran stock exchange based on financial ratios using DEA (The case of chemical & medical company)**

Abstract: Many chemical & medical companies embark on process improvement initiatives, but lack evidence that these programs result in high efficiency. Therefore, the purpose of this study is to examine the performance of chemical companies listed in Tehran Stock. The study uses data envelopment analysis (DEA) to understand Chemical company efficiency and

effectiveness a survey to understand the chemical process improvement implementation. To measure the performance of companies, the total assets, equity, and ADS was used as inputs and outputs consist of NPM, ROE, and ROA. In the course of this research, formulation of hypotheses and systematic removal of 32 companies by stock exchange, the 5-year period 2011-2015 were selected with reference to their financial statements, the information necessary to measure the variables, extraction and statistical tests on they were carried out. The results of the DEA indicate the existence of different degrees of financial ratios in medical and chemical companies. When by Anderson Peterson model, companies can be ranked and categorized into three groups: strangely super-efficient, supper-efficient and efficient.

Paper ID: P30
Author(s): Iswahyudi Sondi Putra
Title: **Measurement of oil and gas upstream industry performance in Indonesia: A data envelopment approach.**

Abstract: Oil and gas industry has capital-intensive, technology-intensive, and high-risk characteristics. In addition, the application of different fiscal systems in a number of nations will affect the calculation of the revenue of oil and gas companies. In order to measure the efficiency of upstream oil and gas industry, the above mentioned oil and gas industry characteristics should be taken into account. These characteristics will influence the determination of output and input variables. Indonesia use Production Sharing Contract system in fiscal systems. With this system, the operational management is in the hand of the Government of Indonesia (GOI), whereas the oil and gas companies act as a contractor. The GOI requires a method to assess the effectiveness of a policy applied in oil and gas upstream sector. This paper offers an efficiency measurement method for oil and gas upstream sector that operate in Indonesia by employing DEA method. If the GOI's policy is successful, the efficiency in the oil and gas companies in upstream sector will increase. The results of this research show that the DEA method can be used by the GOI to see the performance in oil and gas upstream industries.

Paper ID: P33
Author(s): Nasser Amani and Hadi Bagherzadeh Valami
Title: **Application of Malmquist productivity index with carry-over index in power industry**

Abstract: Better performance (efficiency) does not necessarily mean a better work (effectiveness) and productivity depends on both efficiency and effectiveness. In data envelopment analysis (DEA), there are different methods for measuring changes in total factor productivity of decision making units (DMU) in different times using different technologies. One of the most important of all is Malmquist productivity index. These days in many economical and industrial activities namely investment and the energy, there are some indexes which transform among different periods and would results in affecting the function of a DMU in other period based on the function of a DMU in a specific time period. These indexes may vary from time to time i.e. in a time interval they may be good and in another one they may be bad, which they tended to be ignored in traditional Malmquist productivity index. In this paper we developed the Malmquist productivity index by considering transforming indexes using non-radial model (SBM) in variable returns to scale (VRS) style and then benefiting that model, we analysed the electricity industry of Iran in two consecutive years.

Paper ID: P34
Author(s): Janet Ganouati and Stéphane Vigeant
Title: **Optimal portfolio selection under higher moments: DEA cross-efficiency approach**

Abstract: In this work, we present a model that can be used to portfolio selection. This model applies data envelopment analysis cross-efficiency - an approach, which had been widely used for ranking performance of decision making units. The simple use of cross efficiency scores in portfolio selection as such suffers from the lack of portfolio diversification problem of resulting portfolios. This poor diversification issue is compounded due to the ganging-together phenomenon of DEA cross-efficiency evaluation. In fact, this problem get worse because the simple use of cross-efficiency evaluation in portfolio selection fails to consider inter-DMU risk involved in a portfolio with respect to change in weights although it can effectively reduce individual DMU risk. This issue is addressed by incorporating DEA cross-efficiency evaluation into the mean-variance-skewness-kurtosis framework. Moreover,

our approach permits to portfolio selection with best resource allocation. The robustness of this approach is highlighted by using (Ledoit & Wolf, 2008) Sharpe test. We apply this framework to portfolio selection using a sample of firms listed in Paris stock exchange from 2010 to 2015.

Paper ID: P35
Author(s): Chandra Raman and Rajbhir Bhatti
Title: **Performance measurement of heavy equipment dealerships using data envelopment analysis (DEA)**
Abstract: Measuring and improving performance of organizations has always been the focus of the top management with a view to improve profitability and especially true in the competitive business environments of the day. DEA provides a data oriented approach to measure relative efficiency when there are multiple business units. DEA has been successfully used in public sector and private sector organizations to measure the performance but one of the industries that has not been studied from this perspective is the heavy equipment industry. The objective of the present study is to measure the relative efficiency of heavy equipment dealerships having thirty business units. In the first study the relative efficiency is measured using the black-box approach of DEA and in the second study NDEA will be used to measure relative efficiency of these DMUs to get a deeper understanding of how efficiency can be improved. The study uses six inputs and four outputs for the black-box approach and also studied the change in efficiency over a period of five years. The result of the study helped in identifying the most efficient branches of dealership and in improving the efficiency of inefficient branches.

Paper ID: P36
Author(s): Amar Oukil and Srikrishna Madhumohan Govindaluri
Title: **Towards an efficient approach for ranking football players worldwide**

Abstract: The ranking of players has always been an important input for major decisions in the football industry. The existing ranking approaches are predominantly judgmental. Based essentially on the opinion of field experts, such as reporters, and former football

players, rather than factual data, the process is perceived as subjective. Therefore, developing a methodology relying on more objective criteria appears as an important step towards a fair ranking of football players. In our paper, we discuss a framework that integrates data envelopment analysis (DEA) and ordered weighted averaging (OWA) operators. A sample of players from European Premier League Football clubs are selected and ranked under a decision setting that involves desirable and undesirable factors.

Paper ID: P38
Author(s): Sahand Daneshvar and Mustapha D. Ibrahim
Title: **A new efficiency improvement direction in data envelopment analysis: Based on most productive scale size**

Abstract: Data envelopment analysis evaluates the relative efficiency of operating units. Improving the performance of inefficient units infers finding a target point on the efficiency frontier for the inefficient units. In this paper, a normal vector based on most productive scale size (MPSS) is proposed as a direction for improvement for the inefficient units. The idea behind this approach is that MPSS is an appropriate benchmark for inefficient units, thus improvement on the premise of MPSS direction is possible for units in the production possibility set (PPS). We show that the proposed method can be a logical option for transforming an inefficient unit via simultaneous improvement of its inputs and outputs.

Paper ID: P39
Author(s): Bahareh Vaisi
Title: **Productivity improvement in a manufacturing system using computer simulation: A comparison between DEA and DEAGP**

Abstract: Generally, improving production rate is a typical crucial problem in any manufacturing system. To cope with the problem, different kinds of scientific method stems from trial and error may be applied which imposes high costs. Rottenly testing any proposed scenarios may have significant effect on both operational management and manufacturing cost. This paper considers a simulation, once based data envelopment analysis (DEA) and

once again based data envelopment analysis goal programming (DEAGP) applied into a well--known automobile spare part manufacturer in Iran to improve production rate. The purpose is to select the optimum scenario, which could maximize the system efficiency as well as make a comparison between DEA and DEAGP. The techniques of Monte Carlo simulation and linear programming adopted to solve the problem. In order to make the frame efficient, once the DEA and the other time DEAGP model improved according to the features of the system simulation. Applying these methods could conduct us to gain more than 1% improvement in production rate using the existing resources.

Paper ID: P42
Author(s): Don Galagedera, Israfil Roshdi, Hirofumi Fukuyama and Joe Zhu
Title: **Intermediate resource imbalance in network DEA: Assessment and implication on overall and stage level performance**

Abstract: Mutual fund is a popular investment vehicle for investors. Investors usually judge fund manager performance relative to target benchmarks. Fund managers, on the other hand will also be interested in how they perform in different aspects of fund management. To get more insights on this, fund management function is conceptualized as a three-stage production process. We argue that the three stage-level processes operate under similar/ different risk profiles. When two individual stage-level processes have similar risk profiles, we assume that there is no internal resource imbalance (IRI) and when they have different risk profiles we assume that there is potential for IRI. We formulate a network DEA model to assess MF performance by imposing structure on the intermediate variables that link multiple stages and introduce a new metric to measure IRI of the overall fund management process. A network data envelopment analysis model is developed to assess overall and stage-level performance. A metric developed to assess linkage performance is shown empirically to add discriminatory power of performance. Further applications and direction for extension of the proposed model is discussed.

Paper ID: P43
Author(s): Victor John Cantor and Kim Leng Poh
Title: **A modified SBM-NDEA approach considering non-homogeneity of sub processes**

Abstract: The traditional DEA models treat DMUs as black boxes whose internal structure is ignored. Recently, network DEA models have been introduced that treats the internal structure of a DMU as a network system. The increased interest in network DEA also produced different type of model formulations including the SBM-NDEA. SBM is a non-radial approach suitable for measuring efficiencies when inputs and outputs may change non-proportionally, which is a sharp contrast as compared to traditional DEA models that measures input and output changes proportionally. However, just like other DEA models, SBM-NDEA has its assumptions that limit its applicability and discriminative power in efficiency measurement. The proposed model differs from existing SBM-NDEA approaches in that it (a) considers the exogenous inputs and outputs at the system level instead of at the process level, (b) takes into account the presence of intermediate products in the model's objective function, and (c) applies into a more general scenario considering no matter what type of input and output measures are consumed and produced, respectively.

Paper ID: P44
Author(s): Sören Guntram Harms, Mohsen Afsharian and Heinz Ahn
Title: **An alternative meta-frontier Malmquist index for measuring productivity over time**

Abstract: This paper proposes an alternative meta-frontier Malmquist index for measuring productivity over time, where the panel data comprise groups of decision making units (DMUs) operating under different local technologies. In such situations, the group's managers apply their individual management concepts, customized strategies and local procedures, taking also into account different environmental constraints of their subordinated DMUs. The proposed approach overcomes a weakness of the conventional Malmquist index, which implicitly neglects that the technology under which each group of DMUs operates can change over time. This negligence may lead to a poor approximation of the meta-frontier and accordingly to misleading results and managerial conclusions. Improving the estimation of the meta-frontier, we show within our approach that individual characteristics of the technology, represented by different

group technologies over time, can be preserved and traced later in measuring productivity change. The proposed approach is illustrated by means of an empirical application to KONE corporation, which is recognized as one of the global leaders in the elevator and escalator industry.

Paper ID: P45
Author(s): Mohsen Afsharian, Heinz Ahn and Sören Guntram Harms
Title: **DEA-based performance comparison of management groups under centralized management**

Abstract: In many real world DEA applications, there are situations where a central body manages a large number of similar units through a few distinct management groups. Each group – with a segregated geographical business area – has its own unique management style in managing its operating units while allocating resources and producing products and/or services to local customers. This paper focuses on the development of an index for comparing the performance of the management groups under such a centralized management. The existing method implicitly applies a relaxed assumption that all operating units in the organization perform independently and pursue their own interest. We argue that this premise is unsuitable in such hierarchically structured organisations as operating units within each group are functioning under a single (central) management team allowing for, e.g., reallocating of resources or transforming of products within the group. From a theoretical point of view and with also an empirical application to KONE – one of the global leaders in the elevator and escalator industry – we will show the capabilities of the proposed index under these circumstances.

Paper ID: P46
Author(s): Ali Ebrahimnejad and Farhad Hosseinzadeh Lotfi
Title: **Fuzzy efficiency measures in data envelopment analysis with undesirable outputs using fuzzy arithmetic approach**

Abstract: Data envelopment analysis (DEA) is a well-known non-parametric methodology for computing the relative efficiency of a set of homogeneous units, named decision making units (DMU). This paper formulates a fuzzy DEA model to deal with (1) fuzziness in input and

output data and (2) undesirable outputs in performance measurement problems. The fuzzy arithmetic approach is generalized for solving fuzzy DEA model in the present of undesirable outputs. The fuzzy DEA model is transformed into linear programming problems to obtain the relative fuzzy efficiency of each DMU. An analytical fuzzy ranking approach is developed to compare and rank the relative fuzzy efficiencies of the DMUs.

Paper ID: P47
Author(s): Ali Emrouznejad, Guoliang Yang and Marianna Marra
Title: **Eco-efficiency considering CO2 emissions and data envelopment analysis: A critical and structured literature review**

Abstract: This work provides a comprehensive literature review of work using data envelopment analysis (DEA) (including the Malmquist-Luenberger productivity index, MLPI) to measure the efficiency and productivity of decision-making units (DMUs), with carbon dioxide (CO2) emissions as an undesirable output. We searched the Web of Science (WoS) academic database and identified a sample of 171 papers published between 1989 and 2016. We apply structured literature search and citation network analysis to reveal the evolution of the literature on this topic. The objective is to (a) examine the key-route main path of the knowledge flows characterizing the topic researched, (b) provide basic bibliometric information on the most active journals and authors, (c) conduct a qualitative in-depth analysis of the most important studies identified, and (d) focus on the most recent period - 2000 and 2016, to identify research topics and relate them to the emerging issues in the area of research. Based on the insights from the literature review, in the second part of the paper we conduct in-depth analysis to provide a critical review of papers on the key-route main path in this area.

Paper ID: P48
Author(s): Shokoofeh Banihashemi
Title: **Portfolio optimization with risk measures VaR and CVaR under VG process in DEA models: A comparison with Gaussian process**

Abstract: As we know, there is a belief in the finance literature that value at risk (VaR) and conditional value at risk (CVaR) are new approaches to manage and control risk and are shown as new measures of risk. Without considering the skewness and kurtosis or assets

return rate, optimization with Gaussian underestimate the optimal CVaR and VaR of portfolio. This paper focuses on describing the dynamics of assets' log price with Variance-Gamma process (VG) and compare with Gaussian process. For this purpose, focuses on the performance evaluation and portfolios selection by using data envelopment analysis (DEA) and compare variance-gamma (VG) process and Gaussian process in calculating VaR and CVaR. Then, these risk measures are considered as a constraint of risk and are decreased by using negative data models in DEA. Finally, a numerical example with VG process by Monte Carlo simulation is conducted to calculate conditional value at risk and determine efficiencies that can be obtained by mean-CVaR framework.

Paper ID: P49
Author(s): Mohsen Rostamy- Malkhalifeh and Motahare Ebrahimzade-Adimi
Title: **A new linear method to finding congestion hyperplane in DEA**

Abstract: The congestion is known as inefficiency but it is different from the concept of technical inefficiency that has already been identified. The important point is that no method has been able to determine the congestion border yet. Also, sometimes not paying attention to the condition of convexity, the amount of congestion on some of the congestion units, zero is calculated. In this article to fix the problem and reducing the calculations, regardless of the amount of efficiency of units under evaluation, will be introduced the congestion Hyperplane that will not only create a border between units that occurred the congestion in them and efficient units, moreover the distinction is made between technical efficiency and congestion units. Also, the distance between decision-making unit and the hyperplane, will determine the amount of the congestion in congestion units furthermore it will indicate the maximum amount of increase in inputs for the efficient units or inefficient units to be on the verge of the congestion. On the other hand, it can be completely determined all units that the congestion is occurring in them.

Paper ID: P50
Author(s): Yao-Yao Song and Guo-Liang Yang
Title: **Measuring the productivity evolution of Chinese regional thermal industries using Malmquist-Luenberger productivity index**

Abstract: Chinese thermal power industry has experienced rapid development recently, and it has become the major way of Chinese power generation. But it turned to be the major source of air pollution in China because it relies on the consumption of coal. To solve the resource consumption and environmental pollution problems, the productivity of Chinese thermal industries have aroused widespread concern in society. In this paper we use data envelopment analysis (DEA) and global Malmquist-Luenberger productivity (GMLP) index for measuring the productivity evolution on Chinese regional thermal industries. The results reveal that although the change of technical efficiency and scale efficiency had different influence in each year among different regions, the overall GMPL index change shows a close relationship with the contemporaneous frontier shift, which indicates that Chinese government should focus on the promotion of the implementation of policy and regulations in thermal industries for the purpose that the contemporaneous frontier can shift toward the global technology frontier in the direction of more desirable outputs and less undesirable outputs.

Paper ID: P53
Author(s): Jesus T. Pastor, Juan Aparicio and Vidal Jiménez Fernando
Title: **The weighted additive distance function**

Abstract: Distance functions in production theory are mathematical structures that characterize the belonging to the reference technology through a numerical value, behave as technical efficiency measures when the focus is analysing an observed input-output vector within its production possibility set and present a dual relationship with some support function (profit, revenue, cost function). In this paper, we endow the well-known weighted additive models in data envelopment analysis with a distance function structure, introducing the weighted additive distance function and showing its main properties and applications.

Paper ID: P57
Author(s): Abdollah Noorizadeh and Antti Peltokorpi
Title: **A key supplier efficiency analysis in construction projects: application of data envelopment analysis**

Abstract: Limiting the long-term relationship to most important suppliers is recognized among the driving factors to improve a buying company's performance. In project-centric environment with discontinues production settings, it is important to recognize the key suppliers with significant contribution to a company's performance. Hence, to build an effective supplier-buyer relationship in project business, we apply data envelopment analysis (DEA) for the key supplier efficiency analysis in construction projects. These suppliers most often are invited to take a part on a wide range of projects and they provide large share of materials and work tasks to the construction company. Analysing the performance of these suppliers can help the company to improve its projects quality and provide the negotiation opportunity to reduce the costs of supplied materials and work. It also raises awareness among other suppliers to try for performance improvement if they want to be remained in relationship with the company. In this study, therefore, the key supplier performance in construction projects is evaluated to enhance the construction company's understanding of performance improvement possibilities.

Paper ID: P58
Author(s): Andreas Dellnitz and Andreas Kleine
Title: **RTS-Mavericks in DEA: A first application for cross-returns to scale**

Abstract: Data envelopment analysis (DEA) is a non-parametric method to estimate (in-) efficiency scores of ex-post production activities of comparable decision making units (DMUs). In the BCC model – the case of variable returns to scale (RTS) – one can determine the RTS values for all DMUs; these values then permit information for deciding whether the activities should be up- or down-sized. But sometimes the RTS values are – from a decision-maker's point of view – abnormally high or low and hence impracticable. Dellnitz (2016) identified such kind of DMUs – named RTS-mavericks – via a median-based outlier test, and proposed scale restrictions for handling this situation. However, in exceptional cases this deployment of

lower and upper scale bounds does not necessarily lead to a revised RTS value. In this contribution we focus on this problem and, therefore, develop a method that bases on cross-evaluation to cure this deficit. The new concept will be illustrated by a small numerical example.

Paper ID: P60
Author(s): Laurent Cavaignac and Romain Petiot
Title: **The contributions of DEA to airports efficiency analysis: A 20 years meta-analysis**

Abstract: The steady growth of airport traffic caused by deregulation during the last thirty years generated tensions on airports management and raised the question of airports efficiency. Take as proof the constant increase of research articles on airports efficiency in the literature (Bezerra and Gomes, 2016). Some of the main questions are that of the impact of public subsidies, public service delegation or privatization or of airport size on airports efficiency? The most commonly used efficiency analysis tools are stochastic frontiers analysis (SFA) and data envelopment analysis (DEA). Over the last 20 years, 116 articles focused on airport efficiency using the DEA method (Cavaignac and Petiot, 2017). In this paper, we present the results of a meta-analysis of these articles. First, we evidence the influence of the data year, the data geographic origin, the number of airports, the returns to scale assumption, the model orientation and the type of input and output on efficiency results. Second, we outline the most robust results in order to inform public policy and practices.

Paper ID: P61
Author(s): Romain Petiot and Laurent Cavaignac
Title: **Performance analysis of French logistics services providers: A first data envelopment analysis**

Abstract: The research debate on the key factors of logistics performance is in full swing. The logistics services providers (LSP) sector forms a major pillar of the supply chain performance. This sector is undergoing profound changes. There have been many mergers and acquisitions which tend to decrease competition and the pressure on cost efficiency. This raises the questions of the performance of the firms in this sector and their optimal size. Research in this field is scarce and no analysis has been conducted on the French market (Mothilal, 2011). Data envelopment analysis (DEA) is typically adapted to answer such questions

(Min and Joo, 2006, 2009; Zhou et al., 2008). In this paper, we provide a data envelopment analysis of the logistics services providers on the French market. We use a database from 2014 to determine efficiency benchmarks, inefficiency measures and return to scales for 79 French LSPs. To improve the robustness of our results we use bootstrap techniques. A tobit model is then implemented to identify the influence of environmental variables such as the LSP status (international or national), the area of specialization, etc.

Paper ID: P62
Author(s): Indranil Bardhan and Chenzhang Bao
Title: **Measuring the relative performance of accountable care organizations using DEA**

Abstract: Accountable care organizations (ACOs) represent healthcare delivery organizations which consist of groups of doctors, hospitals, and other health care providers, who provide coordinated, high quality care to patients that they serve. We propose a conceptualization of ACO relative performance, based on their capability to convert clinical and staff resources, into quality indicators of patient health and safety. We address two research questions: (a) what is the impact of ACO size on relative ACO performance, and (b) does health information technology moderate the impact of ACO size on performance? We test our models using two years of a nationwide sample of ACO data for two years: 2014 and 2015, using a two-stage DEA and regression estimation approach. Our results indicate that larger ACOs, as measured by assigned beneficiaries, are likely to exhibit lower performance levels relative to smaller ACOs, in terms of their ability to convert clinical and non-clinical resources into process quality outcomes. However, we find that usage of electronic health records mitigates the negative impact of ACO size. Implications for healthcare policy makers and researchers are discussed.

Paper ID: P63
Author(s): Leonid Galchinsky and Andriy Svydenko
Title: **Evaluating the effectiveness of market prices in the petroleum products market for DEA methodology**

Abstract: The market of the petroleum products has been and remains a major component of energy supplies for the economy. Characteristically, the vast majority national markets of the world fuel market are oligopolistic and sensitive to fluctuations in external factors.

In turn, this leads to non-optimal redistribution of resources and, consequently, reducing the efficiency of market mechanisms. The welfare economics says that pricing efficiency in terms of the welfare of society manifested in the absence dedweight loss. But comparing of the market volume and market dedweight loss on the petroleum product market is difficult problem. This paper proposes to solve this problem by using the methodology of DEA. The main output parameters that define the quality of the petroleum products market are: market size and level dedweight loss. Input parameters is the infrastructure of retail sales and the index of concentration market, GDP per capita, the number of vehicles in the characteristics of the consumers and the tax burden in the retail price of petroleum products is comparable to the efficiency of market and point out the main ways that can help improve it.

Paper ID: P64
Author(s): Patcharaporn Yanpirat, Suneeporn Ounsamai and Sansanee Supapa
Title: **Integrated balanced score card and total quality management in supplier performance measurement using the combined methods of factor analysis, VAHP and multistage data envelopment analysis: A case study**

Abstract: The rapid changes in business environments and recent environmental disasters have played important roles in affecting the competitiveness of firms in supply chain management. An appropriate performance metric can be considered as alternative risk management in addition to an effective method for the performance measurement of suppliers, which can enhance the competitive advantage of firms under the anticipated situations. The objective of this paper is to propose a performance measurement framework in terms of procedures and combined methods by employing integrated concepts of balance scorecard and total quality management in supplier performance measurement under the aforementioned complex system. Combined factor analysis and voting analytic hierarchy process are used to set the performance metric and its hierarchy, and multistage data envelopment analysis is used to measure the performance of the expected suppliers. A case study is used to demonstrate the procedures and the methods of implementation.

Paper ID: P65
Author(s): Iveta Palečková
Title: **Technical efficiency of selected CEE banking sectors applying the dynamic DEA model**

Abstract: The objective of the paper is to estimate the technical efficiency of 10 CEE banking sectors using the dynamic data envelopment analysis. In line with the aim of the paper we also determine whether banks that belong to a financial conglomerate are more or less efficient than other banks in the banking sector. The observed CEE countries include the banking sectors of the Czech Republic, Slovakia, Poland, Hungary, Romania, Bulgaria, Bosnia and Herzegovina, Croatia and Serbia. First, we estimate the relative efficiency using the dynamic data envelopment analysis (DEA), the slack-based measure model with variable return to scale. The dynamic DEA estimates efficiency of a group of DMUs during several periods of time. Additionally, each DMU has carry-over variables that take into account a positive or negative factor in the previous period. Next, we analyse the individual banks of financial conglomerates. We investigate banks from four financial conglomerates (Erste Group, KBC Group, Société Générale Group and UniCredit Group). We analyse whether these banks achieve a value above or below the median value in each observed country.

Paper ID: P66
Author(s): Maryam Mohaghegh Tabar
Title: **Modified super-efficiency data envelopment analysis models for fixed input allocation problems**

Abstract: This paper considers the fixed cost allocation and the fixed resource allocation along with target setting, in the framework of data envelopment analysis. It is assumed that decision making unites are under the condition of variable returns to scale.

We solve the two problems by using modified super-efficiency models. Numerical examples show the practicality and advantages of our proposed approach.

Paper ID: P67
Author(s): Shahin Ashkiani and Cecilio Mar Molinero
Title: **Visualization of cross-efficiency matrices using multidimensional unfolding**

Abstract: This study suggests a method to visualize asymmetric cross-efficiency matrices (CEM) using multidimensional unfolding (MDU). Through such exploratory data visualization, a large number of digits can be comprehensibly represented in a single map, and hidden patterns and structures of the data can be revealed in a holistic approach. CEM is an information-rich data object that not only includes self appraisal, but also peer evaluations of the decision making units (DMUs). As a result, a comprehensive understanding of the DMUs and their relations can be achieved through such visualization. The methodology is illustrated by means of two artificial datasets, and afterwards it is applied on two real datasets. The final maps can be used for anomaly detection. Nevertheless, the usage of this data exploration tool can go beyond anomaly detection, based on the goals of the researchers.

Paper ID: P68
Author(s): Nur Fatin Bari'Ah and Assoc. Professor Adam Baharum
Title: **An integrated fuzzy DEA-QFD approach in eco efficiency system for Malaysia green airplane assessment**

Abstract: To emphasis on green airplane assessment by converting leftover food wastage into extra fuel that will generate electricity in the case of out of power supply is one of the major concerns to travellers. They have found the system in Malaysian airplanes that just putting the wastage in laboratory is not sufficient at all. In response to this issue, the present study aims to investigate the level and factors that will improve the wastage efficiency system focusing in Malaysian airplanes. This paper provides a novel integrated structure of fuzzy DEA-QFD that concentrate in eco-efficiency system for future improvised system for assessing green airplane assessment. A case study between two Malaysian airplanes in Malaysia will illustrate the proposed integrated method. The analysis confirmed that improvement level of wastage conversion into extra fuel will sustain the eco efficiency of environmental performance.

Paper ID: P69
Author(s): Raziyeh Heidari, Reza Tavakkoli-Moghaddam, Reza Yazdanparast and Leyla Aliabadi
Title: **A fuzzy data envelopment analysis for assessment of supply chain resilience: An Iranian car manufacturer**

Abstract: Today's complex supply chains are increasingly susceptible to the turbulent and fast-changing business environment and their economic implications. Resilience as effective strategic planning during disturbances is a way to mitigate supply chain vulnerabilities. After reviewing the literature on the topic of the resilient supply chain, this paper extracts the complete series of 16 resilience enablers. These identified enablers form the foundation of a questionnaire distributed among over 150 experts and staff of a real case associated with an Iranian car manufacturer. The reliability and validity of the questionnaire are evaluated by statistical tests and Cronbach's alpha. Then, a fuzzy data envelopment analysis (FDEA) method is used to evaluate the performance of the resilience enablers in context of supply chain disruptions. Finally, the validation and verification of the obtained results are performed using statistical tests. The case study findings indicate that firms can be less vulnerable in terms of supply chain disruptions by improving the resilience enablers. The proposed framework in this study may find a broad practical application in all types of supply chains.

Paper ID: P70
Author(s): Ioannis Gkouvitsos and Ioannis Giannikos
Title: **Using a MACBETH based multicriteria approach for virtual weight restriction in each step of a DEA multi-stage ranking process**

Abstract: This paper proposes a new approach for ranking decision making units (DMUs), which combines existing knowledge with multi-stage virtual weight restriction. The key idea behind our approach lies on the fact that we allow decision makers to apply different weight bounds during each stage of a DEA super-efficiency multi-stage ranking process. The proposed approach enriches the discrimination power of the underlying super-efficiency model, since it provides decision makers with more control over the importance of inputs and outputs in each stage of the ranking process. The different bounds of each stage are obtained using the MACBETH approach. The proposed approach is applied in a real case study,

involving 33 general hospitals of the Greek NHS. In each stage of the multi-stage ranking, the relevant decision makers were able to define different weight bounds. The final rankings, as obtained by our approach, indicate that our proposed methodology can indeed increase the discrimination power of the conventional super-efficiency DEA model and improve DMUs ranking.

Paper ID: P71
Author(s): Anand Venkatesh and Shivam Kushwaha
Title: **Efficiency of test cricket teams using data envelopment analysis**

Abstract: Test cricket is a unique in the sense that it extends to five days, often without result. Hence it is a test of players' technique and temperament. There are eight major test cricket playing countries. Several analysts routinely rank test cricket teams. In this study we compute the efficiency of each test cricket team over five years. This enables one to assess the efficacy with which each team utilizes resources at its disposal. Two variants of data envelopment analysis (DEA) are used, the output oriented radial DEA and the Pareto-Koopmans non-radial DEA, which is completely "slacks free". In alternate DEA models, the outputs are either percentage of wins, win and draws or home wins and away win and draw respectively. The inputs are average runs scored by a team in the first and second innings respectively and the wickets per run conceded in each innings. Assuming non-regressive technical change, each team's average performance over every year of study (2011-15) period is evaluated separately. It is observed that certain teams like the West Indies, perceived to be weak are making full use of their limited resources while more celebrated teams have scope for improvement.

Paper ID: P72
Author(s): Bruno Torres, Mariana Almeida, Lidia Angulo Meza and João Carlos Soares de Mello
Title: **A network DEA approach for the H-index**

Abstract: In this communication we use a NDEA model to analyse the ability of a researcher to transform the scientific production in a larger h-index. We use a relational NDEA model. The exogenous input is the scientific age of the researcher. The exogenous outputs is the

h-index and the intermediate variables are the number of papers published and the number of citations. The first stage of this NDEA model represents the productivity and relevance of the researcher's work taking into account the scientific age. The second stage, the ability of transforming production and citations in the h-index. The overall efficiency links h-index with the scientific age. As the relational approach needs the assumption of constant returns to scale, we need to ensure proportionality. Therefore, we perform a scale transformation in the number of citations. The model was used to analyse the professors of an academic department in Brazil. We have obtained the efficiencies in both stages and have also performed a multipliers analyse. Such analyse shows that two DMUs were forcing null multipliers for all DMUs in the intermediate variable "number of articles". We have identified the reasons for such occurrence.

Paper ID: P73
Author(s): Milan Hladik
Title: **A novel data envelopment analysis ranking based on a robust approach**

Abstract: We propose a novel DEA ranking based on a robust optimization viewpoint: the higher ranking for those DMU's that remain efficient even for larger variations of data and vice versa. This ranking can be computed by solving generalized linear fractional programming problems, but we also present a tight linear programming approximation that preserves the order of rankings. We show some remarkable properties of our approach: It preserves the order of rankings compared to the classical approach. It is naturally normalized, so it can be used as universal ranking of DMU's of unrelated models. It gives ranking not only for inefficient, but also for efficient decision making units. It can also be easily extended to generalized model, for instance to deal with interval data. We present several examples confirming the desirable properties of the method.

Paper ID: P74
Author(s): Helena Brožová and Ivana Boháčková
Title: **Efficiency of the agricultural sector in the Visegrad states – comparisons using Malmquist index**

Abstract: In this contribution we analyse the efficiency of the agricultural sector in the 34 regions NUTS 2 of the four Visegrad states. The regions are characterized by three inputs (agricultural land, annual work costs and gross fixed capital formation) and one output (gross value added). The panel data refers to years 2005, 2007, 2010, 2011, 2012 and 2013. Analysis is provided using data envelopment analysis method and corrected Malmquist index. Efficiency of regions in Poland is higher than in other countries, it could explain by lower cost, mainly work costs, because work of owner family members is not counted. The next country is Hungary and then Slovak. The Czech regions are less efficient because of highest gross fixed capital formation. Malmquist index shows significant increasing of efficiency in period 2005 - 2007 following by negative development in 2007 – 2010 due to economic crisis. In post crisis period 2010 – 2011 the efficiency increasing is seen mostly in all regions but between year 2011, 2012 and 2013 no change can be seen. It means that the agricultural sector is returned into its standard situation without significant change.

Paper ID: P75
Author(s): Amir Shabani, Paolo Barbieri, Wout Dullaert, Daniele Vigo and Franco Visani
Title: **Bridging the gap between supplier total cost of ownership and data envelopment analysis**

Abstract: Data envelopment analysis is a valid alternative for supplier total cost of ownership (TCO) calculations as it requires less effort and time. Contrary to TCO, DEA requires multiple supplier-specific weights to evaluate suppliers' performance. The use of uncommon weights is hard to be accepted by managers. Additionally, managing the information from several cost centres is considered to be time consuming due to the fact that TCO data gathering and processing often involves imprecise data that can be modelled as interval or ordinal preference values. The objective of this paper is therefore to develop a novel common set of weights imprecise DEA model (CSW-IDEA) as a parsimonious approach to TCO calculation

taking into account managerial concerns on the weights, data availability and information gathering. The proposed methodology is validated on real-life data from 120 companies supplying four key components to an international firm. The proposed CSW-IDEA model provides more accurate approximations for the TCO scores (compared to classic DEA models), handles imprecise data, and requires less time and effort for information processing. These supports the use of TCO in practice.

Paper ID: P76
Author(s): Giovanni Cesaroni, Kristiaan Kerstens and Ignace Van de Woestyne
Title: **Short- and long-run plant capacity notions: definitions and comparison**

Abstract: Starting from the existing input- and output-oriented plant capacity measures, this paper proposes new long-run input- and output-oriented plant capacity measures. While the former leave fixed inputs unchanged, the latter allow for changes in all input dimensions to gauge either a maximal plant capacity output or a minimal input combination at which non-zero production starts. The paper also establishes a formal relation between the existing short-run and the new long-run plant capacity measures. Furthermore, for a standard nonparametric frontier technology, all linear programs as well as their variations are specified to compute all efficiency measures defining these short- and long-run plant capacity concepts. Finally, we numerically illustrate this basic relationship between these short-run and long-run technical concepts of capacity utilisation.

Paper ID: P77
Author(s): Shu-Chin Huang
Title: **How can central banks' interest-rate policies affect commercial banks' technological development?**

Abstract: The 2008 financial crisis triggered a period of low interest rate all over the world till the end of 2016. How can central banks' interest-rate policies affect commercial banks' technological development in the short-run and the long-run? The issue is largely ignored by central banks when they implement monetary policies because their major concerns are normally the

macro-economic performance. However, it is important to banking industrial development. In this study, we investigate the relationships by using data of leading commercial banks in Taiwan, Hong Kong, Macau, mainland China and OECD countries from 2007 to 2015. The Malmquist total factor productivity index with metafrontier concept and the system generalized method of moments are applied to show the results. The differences between groups of countries, size of banks, and interest-rate policies are compared in this study. We conclude the contribution of this research in technology policy for the banking sector as well as productivity and financial literature.

Paper ID: P78
Author(s): Finn Forsund, Vladimir Krivonozhko and Andrey Lychev
Title: **On the concept and measurement of frontier smoothness in DEA models**

Abstract: Computational experiments with DEA models show that many inefficient units are projected onto the weakly efficient parts of the frontier when efficiency scores are computed. This fact disagrees with the main concept of the DEA approach, since efficiency scores of inefficient units have to be measured relative to efficient units. As a result inaccurate efficiency scores may be obtained. In our previous work we developed an algorithm for smoothing the frontier. This algorithm was based on using the notion of terminal units. Moreover, it turned out that the smoothness of the frontier can be measured. For this reason, we introduced the notion smoothing factor in order to measure the smoothness of the frontier. This factor has to satisfy the following principles: a) it doesn't depend on units of variables measurement in DEA models; b) the more smoothness corresponds to the less value of the smoothing factor. Our theoretical results are confirmed by computational experiments using real-life data sets.

Paper ID: P79
Author(s): Adeola Osundiran and Prof Felix Okonta
Title: **Application of data envelopment analysis to selected ports in Southern and East Africa**

Abstract: Currently there is little research done on the application of data envelopment analysis models to measure efficiency in the port industry, specifically about the container terminals in sub Saharan Africa. The main goal of this research is to evaluate the data from a panel of ten container ports from 2011 to 2015. These are ports in located in Southern Africa and East Africa. Focus on this area is important because of the following reasons: Competitiveness of Africa's economies partly depend on the efficiency of the African ports. The assessment of efficiency is of critical importance in the management of ports for increased scope of commercial activities in the nations; competition amongst maritime ports is increasing continuously; Literature review has established that inefficiency accelerates costs in the port sector. The organization of the maritime transport sector significantly affects the trade volumes, transport costs and economic competitiveness, therefore making it crucial for ports to adopt to the growing complexities of port management. Data envelopment analysis is a linear programming tool used to measure efficiency when there are multiple inputs and outputs.

Paper ID: P80
Author(s): Skarleth Carrales and Jamal Ouenniche
Title: **Which banking environment is more efficient?**

Abstract: 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.

Paper ID: P81
Author(s): Reza Kazemi Matin and Mahdi Mirjaberi
Title: **Calculating directional scale elasticity in DEA Models with undesirable outputs**

Abstract: Among different characteristics proposed in the literature, we are herein interested in scale elasticity or elasticity of outputs. If the production function is smooth and has an explicit functional form, we invoke its derivatives to calculate scale elasticity. Unfortunately, the necessary condition of above statement is not true in empirical studies while we are working in the framework of data envelopment analysis (DEA). Even worse, the problem becomes more complicated in the presence of undesirable outputs. The notion of directional scale elasticity is introduced to generalize the classic notion and provide a measure for disproportional elasticity of outputs. It makes one capable of studying elasticities in any direction, considering undesirable outputs into account. Tangible geometric interpretations clarify the scheme.

Paper ID: P82
Author(s): Hana Vojáčková, Martina Kuncová and Jaromír Rux
Title: **Data envelopment analysis applied on the potential of the tourism in municipalities**

Abstract: Cultural monuments are one of the key factors in tourism and they influence the economical and social development of the municipality or region. The analysis of the potential of the tourism in municipalities and its comparison can be made by various methods and techniques such as local expenditure model, cost-benefit analysis, multi-criteria evaluation of alternatives or cluster analysis. The method that can give an objective comparison of the size of anthropogenic sphere potentials of individual regions or possibly other territorial

units is data envelopment analysis. DEA models are usually used to find the relative efficiency among homogenous units according to selected criteria (inputs and outputs). According to the data taken from the Czech Statistical Office about the municipalities with extended powers in the Vysocina Region as basic spatial units we try to apply DEA analysis in terms of utilization of cultural and natural heritage for tourism. The main task is to identify the problematic places in this region and afterwards suggest the ways for improvement.

Paper ID: P83
Author(s): Tomas Balezentis, Lingling Hou and Lena Kuhn
Title: **Technical and environmental efficiency of Chinese hog farms measured by a DEA approach**

Abstract: As in many other regions worldwide, economic growth, urbanization and technological innovations have been found to cause shifts in Chinese nutritional patterns. Five provinces were selected to represent the five of the six main geographical and agricultural regions. In this paper, we apply the weak disposability SBM in order to measure the environmental efficiency and shadow prices of undesirable outputs (i.e., chemical oxygen demand and ammonia). The carried out analysis indicates Jilin province has achieved the best performance in terms in the overall efficiency. However, closer look into slacks and shadow prices of undesirable outputs suggest that the latter province has also the largest room for improvements in environmental performance.

Paper ID: P84
Author(s): Hana Fitzová and Markéta Matulová
Title: **Transformation of urban public transport financing and its effect on operators' efficiency**

Abstract: The purpose of this study is to analyse efficiency change of urban public transit in the Czech Republic. The methods of data envelopment analysis (DEA) and the Malmquist index are applied on the data of 19 urban public transport systems in the period 2010-2016. Relation between the changes in efficiency and the way of financing the operation of transport services is explored by standard statistical methods.

Paper ID: P85
Author(s): Luka Neralic
Title: **In memoriam professor Abraham Charnes, 1917 – 1992 on the occasion of hundred years since his birthday**

Abstract: In the first part of the paper a short biography of professor Abraham Charnes is presented. Memories of professor Abraham Charnes during my stay in 1985/1986 as a Fulbright visiting scholar, doing my postdoctoral research with him, in the Center for Cybernetic Studies at the University of Texas AT Austin Texas, USA are also presented. Some references are shown.

Paper ID: P86
Author(s): Pooja Bansal and Aparna Mehra
Title: **Directional distance based super efficiency model for integer-valued data envelopment analysis**

Abstract: The paper develops a directional distance function (DDF) based integer valued DEA model for efficiency evaluation of the decision making units (DMUs) in the presence of mixed real and integer data that can take both non-negative and negative values. The proposed model naturally embeds existence of optimal solution. The paper also proposes a new DDF based super efficiency (SE) integer valued DEA model to discriminate among the efficient DMUs. This model resolves the drawback of infeasibility often encountered in the SE DEA models no matter whether the input and/or output data are negative or non-negative. The proposed SE model is shown to be feasible and bounded. Moreover, we noted that the conclusion made by Lin and Chen (2016), that their SE DEA model for real data can identify inefficient DMUs and their targets, is not always correct. This highlights the need of both the efficiency and the SE DEA models in order to correctly classify the inefficient DMUs and their targets, the efficient DMUs and their super efficiency ranking. Illustrative examples are provided in support of all the results and proposed models.

Paper ID: P87
Author(s): Yongjun Li, Lizheng Wang and Liang Liang
Title: **Robust data envelopment analysis with undesirable outputs: An application to measure performance of National Basketball Association players**

Abstract: This paper develops an approach to deal with the large amount of historical data in the presence of undesirable outputs. For example, when we measure performance of National Basketball Association (NBA) players, players may have a large number of game data, including desirable and undesirable outputs such as scores, assists, rebounds, turnovers and fouls. Based on piror approaches to deal with undesired outputs, this paper develops several corresponding robust data envelopment analysis (DEA) models, and applies the proposed Robust DEA models to measure the performance of National Basketball Association players based on large amount of players' historical data. The numerical results show that the proposed approaches performances well in dealing with the large amount of historical data in the presence of undesirable outputs.

Paper ID: P88
Author(s): Tamás Koltai, Rita Dénes and Zoltán Dénes
Title: **Examination of the effect of patients' functional status on the operation of neuro-musculoskeletal rehabilitation units in Hungary using data envelopment analysis**

Abstract: The efficient operation of public healthcare systems is important in every country as a consequence of the enormous amount of resources spent on serving an aging population. This paper analyses the efficiency of neuro-musculoskeletal rehabilitation units in Hungary using data envelopment analysis (DEA). Data pertaining to all rehabilitation units in Hungary are taken form a country-wide data collection. The operation of neuro-musculoskeletal rehabilitation units is strongly influenced by the patients' functional ability. Rehabilitation of patients recovering after a stroke requires significantly more resources, than the treatment of patients suffering degenerative and inflammatory joint disease or soft tissue rheumatism. Consequently, it is important to consider in the analysis, the aim of rehabilitation and the functional status of patients. The paper shows, how different functional status of patients can be incorporated into an output oriented slack based DEA model using categorical variables. The results confirm that patients' functional ability strongly influences efficiency, but a disadvantageous patient structure may not necessary result in inefficient operation.

Paper ID: P89
Author(s): Mohamad Reza Mozaffari, Josef Jablonsky and Masoud Sanei
Title: **Centralized resource allocation based on the value efficiency in DEA and DEA-R**

Abstract: In this article, centralized resource allocation (CRA) models based on the value efficiency in DEA and DEA-R are recommended. In general, if the input and output data of decision making units is available, DEA models provide patterns of units on the centre of efficiency in addition to the efficiency of units. However, if only a ratio of the input data to output data, or vice versa, is available, DEA models cannot determine the efficiency and pattern of units. In order to solve this problem, DEA-R models are utilized. With a linear programming problem, centralized resource allocation models can achieve the project of all decision making units on the efficiency frontier. Therefore, in the present article the project of inefficient units in DEA and DEA-R is achieved using the CRA models based on the value efficiency (with considering units that the manager defines as MPS). At the end, as applied research for clothing companies of a specific brand is provided.

Paper ID: P90
Author(s): M. Ensar Yesilyurt, Mehmet Dogan Elbi, Ali Emrouznejad,
Mehmet Ulas Koyuncuoglu, Emre Sahin, Filiz Yesilyurt and Aydin Kizilkaya
Title: **Computing single outputs for DEA**

Abstract: In the literature of efficiency and productivity, many studies have been reported to compare the efficiencies obtained by two main methods of DEA and SFA. However one main challenge is that DEA can handle cases with multiple-inputs and multiple-outputs and so makes it difficult to compare its results against the SFA method which could have single output only. This paper aims to first introduce computing single outputs for DEA, which secondly enable us to compare its results against the SFA. Stochastic optimization codes in Matlab and Python have been developed and a simulation study based on many datasets generated form the Cobb-Douglas production function with 100 DMUs, 3 inputs and 3 outputs shows a very good results.

Paper ID: P91
Author(s): M. Ensar Yesilyurt, Filiz Yesilyurt and Ali Emrouznejad
Title: **A comparative study of SFA and DEA for measuring efficiency of hospital in Turkey**

Abstract: This paper deals with measuring efficiency of hospitals in Turkey, specifically we would like to propose a comparative study using DEA and SFA. However one of the issues is that DEA models for hospitals has multiple-outputs while SFA can handle single-output only. This study, therefore, proposes a three stage framework to make this comparison possible. 1) First, we estimate a virtual single-output from multiple outputs using a recent algorithm developed by Yesilyurt et al. (2017), 2) Secondly, we show that both DEA with multiple-outputs and the DEA with estimated virtual single-output produce the same results, 3) Finally, using the virtual single--output estimated in the first stage we can calculate the SFA results and compare them with the DEA results. While the usefulness of the proposed approach has been shown using an application to compare 44 hospitals in Turkey, the framework can be applied to other applications

Paper ID: P92
Author(s): Debora Di Caprio, Francisco Javier Santos Arteaga and Madjid Tavana
Title: **Knowledge accumulation and technological evolution within a dynamic slacks--based measure multi-stage data envelopment analysis model**

Abstract: We integrate the dynamic non-radial slacks-based measure framework of Tone and Tsutsui (2010) with the multi-stage data envelopment analysis (DEA) setting of Khalili--Damghani et al. (2015). Dynamic DEA models are built on the idea that single period optimization is not fully suitable to evaluate the performance of decision making units (DMUs) through time. As a result, these models are designed to measure the changes in efficiency that take place over different periods. Two distinct complementary types of sequentially cumulative processes can be defined depending on the dynamic consistency requirements imposed on the model:
- Carry-over activities between consecutive periods can be used to account for the pervasive effect that technology and infrastructures have on the productive capacity and efficiency of DMUs.
- At the same time, human capital and knowledge, constituting fundamental intangible

inputs, exhibit a cumulative effect that goes beyond the corresponding factor endowment received per period.
We define a dynamic DEA model that accounts for the behaviour and evolution of both types of processes when evaluating both the overall and per period efficiency of DMUs.

Paper ID: P93
Author(s): Subhash Ray
Title: **Production correspondence, technical efficiency and the CCR ratio**

Abstract: Førsund recently argued that the CCR ratio of aggregated output to aggregated input a measure of total factor productivity. Its characterization as technical efficiency has never been seriously questioned because it has been shown to be mathematically equivalent to the Farrell measure of technical efficiency. CCR normalized the virtual input of the unit under evaluation to unity and transformed their linear fractional functional programming problem into a linear programming problem that measures the Farrell radial efficiency under the CRS assumption. This paper starts from a production correspondence that defines a convex technology set exhibiting globally constant returns to scale and measures technical efficiency by the Shephard Distance Function, the inverse of the maximum proportional scaling of the output vector that projects an interior point on to the frontier. Using the well--known properties of a homogeneous function of degree 0 the paper directly shows that the CCR ratio measures the Shephard distance function.

Paper ID: P95
Author(s): Yujiao Xian and Ke Wang
Title: **Carbon emissions abatement cost savings from trading: A parametric and non-parametric combined estimation of China's pilot carbon trading markets**

Abstract: China has launched the pilot carbon emission trading markets in seven provinces and cities, and is planning to establish a unified nationwide carbon emission trading system in 2017. The carbon emission abatement cost savings from trading can be considered an efficient approach to evaluate the necessity and efficiency levels of carbon emissions trading markets, as well as to explore the potential gains from carbon emission trading in China. This

study employed a parametric and nonparametric combined directional distance function technique to calculate the carbon dioxide emission abatement cost (i.e., shadow prices) in the selected industry sectors of China's pilot carbon dioxide emission trading markets during the period of 2011-2015, and provide an estimation of carbon dioxide emission abatement cost savings among different industry sectors of six pilot regions (Beijing, Shanghai, Tianjin, Chongqing, Guangdong and Hubei). We take both the spatial trading and the temporal trading between different industrial sectors into consideration in this study.

Paper ID: P96
Author(s): Oncu Hazir and Klaus Werner Schmidt
Title: **A DEA application for multi-mode project planning**

Abstract: In project planning, managers are interested in various performance metrics. In particular, schedule robustness and stability are of high relevance besides classical criteria cost and duration. In this research, the quality of schedules for multi-mode projects is evaluated based on the define performance metrics using different DEA models. To this end, a large pool of candidate schedules is generated by solving the discrete time/cost trade-off problem (DTCTP), which allows project activities to be processed in different modes. Modes define the activity duration and resource needs and there exists an inverse relationship between time and cost. A small set of efficient solutions, determined using the DEA model, can be presented to project managers in various graphical formats for decision support. In addition to determining efficient schedules, an important contribution of this study is a comprehensive analysis of the impact of project network and cost structure on efficiency results. The analysis results are supported by a detailed statistical analysis. This study was supported by The Scientific and Technological Research Council of Turkey (TUBITAK) under grant SOBAG 113K245.

Paper ID: P97
Author(s): Yu Zhao, Yukihiro Maruyama and Hiroshi Morita
Title: **The measurement and categorization of productivity change in consideration of allocative efficiency**

Abstract: We propose a profit ratio Malmquist productivity index (PMI), which can be applied to panel data to measure productivity growth and suitable for situations when producers desire to maximize revenue and minimize cost simultaneously. Moreover, it takes

account of the impact of allocative efficiency change, which means PMI may give a full picture of the source of productivity change. To find the main factor that causes PMI to increase or decrease over time, we decompose the PMI into profit ratio efficiency change (PEC) and profit ratio technical change (PTC). Furthermore, we decompose PEC into technical and allocative efficiency change, and PTC into technical and allocation technical change. Following previous studies of the conventional Malmquist productivity index (MI), a concept of an allocation Malmquist productivity index (AMI) is also proposed. Based on the relationship among PMI, MI and AMI, we categorize the productivity change into six different types which provide more useful information on organization management. We provide a further discussion for an illustrative empirical application to show the applicability of proposed indices.

Paper ID: P98
Author(s): Avijit Bakshi and Deepankar Sinha
Title: **A DEA based framework for proposed merger of public sector banks in India**

Abstract: The purpose of this paper is to suggest a framework for proposed merger of public sector banks (PSBs) as initiated by government of India to bolster the state-owned banks' capital base. The paper conducts two layers measurement of technical efficiency of PSBs before and after their hypothetical merger using DEA. The first layer consists of measuring technical efficiency before and after hypothecated merger of PSBs in align with Narasimham Committee's suggestion. 27 PSBs were merged hypothetically and reduced to 8 based on the premise of restructuring of weak bank by a big asset sized bank. The results indicate that the efficiency of large banks was relegated by weak banks after forced merger. In second layer we tried to consolidate banks according to their returns to scale (RTS) status. The banks in a particular RTS category are merged among themselves based on their capital adequacy. The results indicate that banks in increasing return to scale (IRS) and constant return to scale (CRS) category remained same after merger. Banks in decreasing return to scale (DRS) category upgraded to CRS and IRS category. Two banks in DRS category remained in same position even after merger.

Paper ID: P101
Author(s): Mustapha D. Ibrahim, Mevhibe B. Hocaoglu, Sahand Daneshvar and Aydin Karakuzu
Title: **Efficiency and productivity analysis of surgical departments by modified data envelopment analysis and Malmquist index**

Abstract: Providing efficient and safe diagnostic and therapeutic surgical procedures are critical in terms of both financial productivity and the quality of patient care. Hospital stays that involve operating room procedures have been shown to be more costly than stays that do not involve operating room procedures. This study aims to identify preoperative, intra-operative and postoperative factors in order to develop evidence-based strategies to improve efficiency of surgical departments. We therefore perform an efficiency evaluation using data envelopment analysis (DEA), and productivity assessment using Malmquist productivity analysis of surgical departments of public hospitals in north Cyprus by considering operational and quality factors of an operating room. The most contributing factors responsible for efficiency and productivity are identified, and recommended as improvement strategies for the hospital management.

Paper ID: P102
Author(s): Rolf Fare, Giannis Karagiannis and Shawna Grosskopf
Title: **On technical inefficiency indicators at the industry level**

Abstract: We show how alternative measures of technical inefficiency using directional distance functions may be aggregated to the industry level. Industry technical inefficiency may be evaluated along different direction vectors; here we show how they are related to one another. Our result indicates that aggregate efficiency evaluated relative to the industry aggregate input-output vector (as opposed to the average input-output vector) is equal to the average of individual efficiency scores evaluated relative to the average input-output vector.

Paper ID: P104
Author(s): Sadiye Eylul Sadanoglu
Title: **A multi-stage dynamic network data envelopment analysis model for evaluating supply chain sustainability**

Abstract: Performance evaluation of supply chain (SC) has a vital impact on SC management and can raise efficiency of entire system. One of the powerful performance evaluation tools is data envelopment analysis (DEA). Nevertheless, the traditional DEA treats decision making units (DMUs) as a black box by only considering initial inputs consumed and final outputs produced by them. There is a lack of understanding of how each stage of SC and how each of its activities interrelated and impacts on overall SC performance. In addition, the traditional DEA models do not reflect the dynamic changes over time. To overcome these gaps, we develop a multi-stage dynamic network DEA model (MDN-DEA) to assess SC sustainability from three dimensions: economical, environmental and social. The significance of including the multi-stage feature into the new model is due to the fact that most real-life SC networks deal with the situation of multiple stages and multiple products. The MDN-DEA model focuses on the evaluation of SC processes in order to maximize economic returns, minimize environmental impacts and meet social expectations.

Paper ID: P107
Author(s): Nazila Aghayi and Bentolhoda Maleki
Title: **The Malmquist productivity index with interval data and undesirable outputs**

Abstract: In this paper, an integrated approach of data envelopment analysis (DEA) and Malmquist productivity index (MPI) is presented to evaluate the performance of decision making units by using the directional distance function in the presence of undesirable interval outputs. Malmquist index calculation is performed to compare the efficiency of units in distinct time periods. One of the advantages of this index is that, in addition to being practical in terms of producing multiple inputs and outputs, it can easily be computerized. In fact, the Malmquist productivity index is calculated for each unit in the best and worst-case scenarios, and then an interval is defined for the Malmquist productivity index of each unit, reflecting the unit's advancement or regress. Finally, results from employing proposed approach in a simple numerical example is analysed.

Paper ID: P108
Author(s): Mehdi Effatparvar
Title: **Load balancing approach based on DEA in grid computing environment**

Abstract: Grid computing is one of the most popular techniques for high performance computing. Grid computing allows users to scale up and down their resource usage based on needs. Grid computing is one of the latest and upcoming paradigms that offer huge benefits such as reduced time to market, unlimited computing power and flexible computing capabilities. This paper discusses load balancing as a mechanism to resource management and distributes the workload evenly to all nodes in the system to achieve suitable makespan and user satisfaction. This paper proposes a new load balancing technique for load balancing with data envelopment analysis method. We evaluate our method based on GridSim simulator and discuss about its advantages and disadvantages.

Paper ID: P110
Author(s): Sheng Ang, Menghan Chen and Feng Yang
Title: **A DEA cross-efficiency evaluation for Taiwan hotel groups**

Abstract: We use DEA cross-efficiency evaluation to assess performances of Taiwan hotel groups. Aggressive secondary formulations are designed to analysis individual and group performance.

Paper ID: P114
Author(s): Wenqiang Bao and Subhash Ray
Title: **Productivity growth and its components in Chinese agriculture**

Abstract: In this paper, we use newly constructed county-level input and output quantity data to measure the Malmquist productivity indexes and its components of multi-factor productivity for each county over the period from 1983 to 2010. We investigate the temporal and spatial nature of productivity and its components growth of Chinese agriculture in Shanxi province. The results of this study indicate that the Malmquist productivity index over the 1983–2010 periods was 1.2% annually for the entire province. Decomposition of the Malmquist

productivity index shows that technical change contributed to the growth in productivity by 0.8% per year, while efficiency change increased productivity by 0.4% per year. The results also show that the Malmquist index of productivity changes is fast-, moderate- and slow--growing in different groups. The trend of the growth of productivity is also explained in this study.

Paper ID: P115
Author(s): Ana María Reyna, Hugo Fuentes and José Antonio Nuñez
Title: **The low interest rates environment and the performance response of the Mexican insurance companies**

Abstract: Operating earnings and investment yields of technical reserves are the two main sources of insurers' income. For its part, investment return contributes to maintaining the minimum amount of capital demanded by statutory regulations and is also a cushion against unexpected increases in claims. In the past, when investment return was higher than expected, it increased profit or allowed more operating costs. Hence, after a continuous declining of interest rates, insurers had to take actions to recover their margins. The purpose of this research is to examine whether insurers improved their economic performance as a reaction to the prolonged period of low interest rates. In a first stage, the performance measure of insurance companies is estimated applying Data envelopment analysis from 2003 through 2015. Then, estimates of efficiency are regressed on macroeconomic variables and firm-specific characteristics. Since it is known that individual companies have different interest rate sensitivity, it is expected as a result of this research to find out what factors distinguish insurers with efficiency management as a response to the prolonged period of low interest rates.

Paper ID: P116
Author(s): Arif Muhammad Tali, Tirupathi Rao and Qaiser Dar
Title: **Non-radial DEA models in series type two-stage production processes**

Abstract: The basic objective of DEA is to evaluate the efficiency of a DMU relative to an empirical production possibility frontier determined by all DMUs under appropriate assumptions regarding returns to scale and orientations. DEA does not consider the internal

operations of a DMU. Rather, DEA treats each DMU as a black-box by considering the inputs consumed and outputs produced, while neglecting the internal process. This perspective is often inappropriate and insufficient; as such approach provides no insight regarding the locations of inefficiency and will not able to improve the efficiency. Thus to get insights into the problem, it is necessary to see what is happening in the black box. Two-stage DEA is a technique which helps in locating the inefficiency in the system. In this study, we are formulating non-radial (Slack-based) DEA models to all possible types of two-stage series production processes. Some types of two-stage processes were illustrated with numerical examples. We also extended it to multi-stage series process.

Paper ID: P118
Author(s): Asmita Chitnis and Shivam Kushwaha
Title: **Assessment of technical and scale efficiencies of Indian drug and pharmaceuticals industry using data envelopment analysis**

Abstract: Technical and scale efficiencies are crucial for a firm in order to evaluate sustainability and intra-industry performance. In this paper, data envelopment analysis (DEA) is applied to Indian pharmaceutical industry (IPI) for the financial year 2015-2016. A sample of 80 firms is used to build the frontier using Pareto-Koopmans's DEA approach. It is found that 13 firms are Pareto-Koopman technical efficient, 17 are scale efficient while 5 of them are both. Only 6.25% are doing well in terms of conserving resources as well as operating at right scale. As compared to domestic firms, foreign firms are operating at higher scale efficiency by 8%. In the second stage, technical efficiency scores are regressed against contextual variables. Interestingly, it is found that age of the firm doesn't have significant impact on the technical efficiency of the firm but marketing expenses and assets of the firm do have. This study could be useful for managerial implication as it will help decision makers to decide their future course of action. This analysis will provide them a guidance to understand where to focus first, whether to conserve resources or to expand/reduce the scale of operation.

Paper ID: P120
Author(s): Shamim Ara, Mahfuza Akther and Farida Parveen
Title: **Technical efficiency of group banks in Bangladesh: using data envelopment analysis (DEA)**

Abstract: In this research, attempts have been made to compare performance of group banks (state owned banks - SOBs, private commercial banks – PCBs and Islamic banks - IBs) in Bangladesh, in terms of technical efficiency using data envelopment analysis (DEA). In this purpose, four SOBs, twenty three PCBs and seven IBs from Bangladesh banking system have been selected systematically. The study period of the analysis is 2006 to 2015. The data have been collected from various issues surrounding the activities of banks, insurances and financial institutions secondary sources. The overall mean value of technical efficiencies is better for IBs than those of PCBs followed SOBs. On the whole, it can be concluded that despite being matured recently in the banking business, Islamic banks are being considered to be efficient with their new ideological principles relative to PCBs and SOBs (CBs). However, to increase banking performance, good banking management and allocation of inputs should be important for the banking system especially for state owned banks.

Paper ID: P124
Author(s): George Vlontzos and Basil Manos
Title: **Assessing the efficiency of olive trees cultivation by implementing the DEA methodology**

Abstract: The production of olives and olive oil in the Mediterranean region is one of the most important cultivation. The continuous changes of the European Common Agricultural Policy (CAP) towards strengthening the influence of market forces, has increased the necessity for assessing the efficiency of production protocols or patterns being implemented by the farmers. The case of olive trees cultivation, despite the fact that it is very important for both farmers and consumers, has not been in depth analysed regarding the efficiency of inputs being used during the production process. This study evaluates the efficiency rates of 100 agricultural holding specialized on olive trees cultivation in Greece, by implementing a DEA input oriented model. The inputs being used are land, fertilizers, agrochemicals, labour, and energy. The output being used is the revenue of each holding. The results quantify the

significant differentiation of efficiency scores, providing evidence that there is space for restructuring the production process, in order to improve efficiency and decrease by this way the production cost of inefficient farmers.

Paper ID: P125
Author(s): Marzieh Moradi Dalini and Abbas Ali Noura
Title: **Using interactive MOLP methods to solve imprecise DEA**

Abstract: The basic data envelopment analysis (DEA) determines efficiency of a set decision making units (DMUs) in exact input-output environments. For imprecise data, some methods have been developed to calculate the efficiency scores. Relation between DEA and multiple objective linear programming (MOLP) conduced to using interactive multiple objective models for solving the DEA problem in exact situation and find the most preferred solution. In this paper, we will show how an imprecise DEA model can be equivalent by MOLP model and using interactive method for solve DEA model with imprecise data.

Paper ID: P126
Author(s): Marzieh Moradi Dalini and Abbas Ali Noura
Title: **PROJECT Method for optimization of DESA model**

Abstract: In this paper, we concentrate on performance assessment of data scenario envelopment (DESA) model with use a comprehensive interactive method with name PROJECT method. Interactive methods in multiple objective programming (MOP) are methods that can help to decision maker (DM) to generate the most preferred solution (MPS). The PROJECT method is able to obtain any efficient solution, contain non-supported efficient solution and also identify the MPS, even in nonconvex cases. This comprehensive model belongs to the class of interactive local trade-off methods, which is generated by combination the projection of the gradient of an implicit utility function on to the tangent plane of efficient frontier and the reference-point method to search for the best compromise solution within a local region. In this study, we will use the DESA model since this model focuses on decreases

total input consumption and increase total output production which results in solving one mathematical model instead of n models, also the PROJECT method to showing the decision maker (DM) preferences in the process of assessing efficiency in the DESA model with any prior judgement.

Paper ID: P127
Author(s): Martin Branda
Title: **Risk-aversion in diversification-consistent data envelopment analysis models**

Abstract: Diversification-consistent data envelopment analysis (DC-DEA) models provide a suitable tool for the decision-makers who want to quantify the performance of investment opportunities available on financial markets. The DC-DEA models are based on risk and return measures and enable to project an inefficient investor's portfolio to the efficient frontier in the risk-return space. Such projection represents a possible way how the investor can revise his/her portfolio to obtain an efficient one. However, there are infinitely many points on the efficient frontier which correspond to the efficient portfolios. We will discuss possible ways how the investor's risk aversion can be taken into account to select a suitable point on the frontier. We will relate our approach to the second-order stochastic dominance efficiency which is nowadays well accepted tool in finance. We will apply the proposed approaches to representative portfolios of US stock market.

Paper ID: P128
Author(s): Thyago C. Nepomuceno, Ana Paula Cabral C. Seixas and Cinzia Daraio
Title: **Methodological and empirical advances in the assessment of the performance of productive efficiency since the introduction of DEA: A bibliometric analysis**

Abstract: The field of productivity and efficiency analysis is growing exponentially, both in terms of new methods and approaches proposed to assess the efficiency of productive decision making units (DMUs), and in terms of innovative and traditional empirical application of existing methods. In this landscape it is interesting to trace the evolution of the field to try to understand recent trends and unexplored areas for further research. This survey

provides a bibliometric investigation on the advances of the data envelopment analysis from the seminal and influential work of Abraham Charnes in 1978 to most recent empirical and theoretical contributions. A time-based mapping and distance-based clusters of the state of the art in the field of productivity and efficiency analysis are developed with the support of CitNetExplorer and VOSviewer analytical tools (Van Eck and Waltman 2014). The visualization of professor Charnes relevant extensions is presented with the identification of applications gaps and evaluation of so far proposed methodologies based on a network of co-citations, providing a valuable reference for researchers to understand the overview and potential advances in this field.

Paper ID: P131
Author(s): Maria Friese
Title: **Task bundling and cost performance: An evaluation of incineration plants using DEA**

Abstract: Bundling of tasks in the form of private-partnership arrangements is claimed advantageous compared to traditional procurement when effort in the first task positively affects performance in the second. I test the effect of bundling the organization and technical operation stages on cost performance using data of 41 garbage incineration plants between 2006 and 2014. I estimate a cost frontier and use a two-step procedure to filter out exogenous influences. I find that inefficiency scores differ by xx % between bundled and unbundled structures.

Paper ID: P132
Author(s): Roohollah Abbasi Shureshjani, Sina Askarinejad and Ali Asghar Foroughi
Title: **Evaluating the efficiency of decision making units in fuzzy two-stage data envelopment analysis models**

Abstract: Data envelopment analysis (DEA) is a technique to assess the efficiency of decision making units with multiple inputs and multiple outputs. Most real life problems contain more than one stage unit which needs multiple-stage DEA models to be solved. Moreover, the inputs and outputs of the units are rarely measured accurately in the real-world problems, hence

fuzzy DEA models can be significantly helpful in calculating efficiency scores. In this study, an appropriate approach for evaluating the performance of decision-making units (DMUs) in fuzzy two-stage DEA models is proposed. The proposed model is a parametric program based on α-cuts. The dependence on α allows the manager to compare and rank DMUs based on his/her degree of certainty and after selection of α, our proposed model becomes linear. Furthermore, a theorem is proposed and proved for conventional multiplicative two-stage DEA models under the variable returns to scale (VRS) assumption. This theorem can be used to check the accuracy of the obtained results. Finally, the proposed approach is illustrated in two different examples and the results are checked with the proposed theorem and the literature.

Paper ID: P134
Author(s): Subhash Ray, Kankana Mukherjee and Abhiman Das
Title: **The MPSS and target setting for optimal scale of Indian bank branches**

Abstract: At the institutional level, a bank is efficient only when its branches are efficient. The overall efficiency of bank branches depends on both technical efficiency and scale efficiency - when a branch operates at the most productive scale size (MPSS) it enhances the overall efficiency of the branch. Bank branches have an incentive to maximize the volume of business and are generally rewarded based on this performance criterion. The objective of this study is to identify branches that are either too small or too large compared to the MPSS and examine how size relates to the performance of branches. We analyse a network of branches of a large Indian bank with national presence and use DEA to study branch level data from the Reserve Bank of India for the year 2014-15. We utilize the method of Cooper et al. (1996) to determine if a given branch is operating at the MPSS. For branches that do not satisfy the MPSS, we utilize the criterion suggested by Ray (2010) to identify if the branch is too small or too large. This can provide useful information for the bank as it plans to grow the size of its branches, open new branches, or close down or merge existing branches.

Paper ID: P135
Author(s): Carla Amado, Sérgio Santos and José São José
Title: **Measuring and decomposing the gender pay gap: A new frontier approach**

Abstract: We develop an enhanced method to measure and decompose the gender pay gap. This method is based on the data envelopment analysis (DEA) technique and on the Malmquist index (MI). We use DEA and the MI to construct an index reflecting an adjusted measure of the gender pay gap, taking into account multiple productive characteristics and multiple types of compensation. Furthermore, we propose a decomposition of the gender pay gap into four components: same-gender compensation gap; cross-gender frontier gap magnitude effect; productive characteristics bias effect; and compensation package bias effect. The method is applied to data from 20 European countries regarding the compensation of business and administration associate professionals working in the finance and insurance industry. The results of the application reveal the existence of a gender pay gap in all countries and that the value of the gap and of its components varies considerably between countries, requiring different policy measures to tackle it. The application also demonstrates the relevance of the method to determine the gender pay gap, to identify its main causes and to delineate effective policies to eliminate it.

Paper ID: P137
Author(s): Qingxian An, Haoxun Chen and Beibei Xiong
Title: **Target intermediate products setting in a two-stage system with fairness concern**

Abstract: In a two-stage system with two divisions connected in series, fairly setting the target outputs for the first stage or equivalently the target inputs for the second stage is critical, in order to ensure that the two stages have incentives to collaborate with each other to achieve the best performance of the whole system. Data envelopment analysis (DEA) as a non-parameter approach for efficiency evaluation of multi-input, multi-output systems has drawn a lot of attention. Recently, two-stage DEA models were developed for studying the internal structures of two-stage systems. However, most of these models are either input-oriented or output-oriented, and there is no work studying fair setting of the target intermediate products. In this paper, a new non-oriented envelopment DEA model taking account of fairness in the setting of the intermediate products is proposed, where the fairness is

interpreted based on Nash bargaining game model, in which the two stages negotiate their target efficiencies in the two-stage system based on their individual efficiencies. This approach is illustrated by an empirical application to insurance companies.

Paper ID: P140
Author(s): Martin Boďa, Martin Dlouhý and Emilia Zimkova
Title: **Technical efficiency measurement with unobservable production variables of differing relative importance**

Abstract: For situations when decision making units carry out their production plans with some inputs or outputs unobservable and when there are a priori known constraints on the relative significance of otherwise observable inputs and outputs, the paper proposes the Weighted Slacks-Based Measure model with Assurance Regions (WSBM-AR) model and demonstrates its utility in performance measurement of bank branches based on technical efficiency. To this end, the paper also incorporates the influence of the external environment into the process of technical efficiency measurement and adapts the proposed model to allow for different sizes and functions of bank branches that appear in the hierarchy of a commercial bank's branch network. Several extensions are formulated and discussed.

Paper ID: P141
Author(s): Hamid Haghighinia and Reza Kargar
Title: **Designing multilayer artificial neural network in order to compare efficiency prediction with the efficiency of provided data**

Abstract: In management's examinations, it is possible that the input parameters are changed by the administrator. For this purpose it is necessary to predict in order to home correct examination. Artificial neural networks are parallel analytical techniques for modelling complex and nonlinear patterns among a limited number of experimental data available. Generally, multilayer neural networks Perception (MLP) uses propagation methods to teach network. To achieve this goal a feedforward neural network model based on nonlinear autoregressive (NAR) for time series is predicted. The learning rule used for regulating the neural net weight, is the Levenberg-Marquardt method. In this article, data collected from

20 branches of mellat bank in 30 time ranges have been used. First the efficiency of DMU is calculated by BCC method and the efficiency of n-th time range, DMUs is calculated by designed MLP neural network. Finally, we'll show that the error between n-th efficiency of predicted data and predicted efficiency of basic data is minimal.

Paper ID: P142
Author(s): Almoghirah Abdellah and Babiker Mohammed Ali
Title: **Rural hospitals in Gezira State: Productive efficiency and its determinant factors 2016**

Abstract: This is a two-stage data envelopment analysis aiming at assessing the technical (productive) efficiency of 51 rural hospitals in Gezira State 2016 and its determinant factors. First, DEA was carried out to calculate the technical efficiency scores under variable returns to scale (VRS) and constant returns to scale (CRS). In the second stage Tobit regression analysis was done. The study revealed that 28 rural hospitals (55%) in Gezira State were found to be efficient and 23 (45%) were inefficient under (VRS), while 23 rural hospitals (45%) were efficient and 28 (55%) were inefficient under (CRS). The mean productive efficiency scores were found to be 0.86 and 0.81 for (VRS) and (CRS) respectively. Technical efficiency was determined positively by the population in the catchment area of the rural hospital, distance from the nearest teaching hospitals and the squared size of the rural hospital. The negative determinant factors included the multiple medical specialties and the number of non medical staff. The study recommended policy implications to improve efficiency of rural hospitals in Gezira State and support better allocation of resources.

Paper ID: P143
Author(s): Victor Podinovski
Title: **Interpreting optimal weights in DEA models with weight restrictions**

Abstract: The interpretation of optimal input and output weights in the standard constant and variable returns to scale DEA models is well known. Such weights are the most favourable for the DMU under the assessment when it is compared to the finite set of observed DMUs. As can be shown by simple examples, in DEA models with absolute or linked weight restrictions this standard interpretation is no longer valid. To overcome this problem, we show that

the optimal weights of DEA models with weight restrictions are still the most favourable for the DMU under the assessment if the latter is benchmarked against the entire technology expanded by the weight restrictions, and not only by the observed DMUs. This interpretation is consistent with the interpretation of weight restrictions as the dual forms of production trade-offs incorporated in the envelopment models.

Paper ID: P144
Author(s): Subhash C Ray, Shweta Nawani and Anand Venkatesh
Title: **Are Indian sugar mills operating at right size? Finding the most productive scale size (MPSS) using DEA**

Abstract: For a convex production technology increasing returns to scale holds along the frontier at any below the (smallest) most productive scale size (MPSS) and diminishing returns prevail beyond (the largest) MPSS. The local nature of returns to scale can be easily determined if a firm is on the frontier. For inefficient firms the input and output oriented projections on to the frontier are different. A firm is too small when both projections lie in the IRS region and is too large if both lie in the DRS region of the frontier. The ambiguous case is one when the input oriented projection implies IRS but the output oriented one falls in the DRS region. Ray (2010) proposed a simple criterion that allows RTS classification by solving a single LP problem to determine the MPSS for any observed input-output combination. This study uses DEA to determine the MPSS for 47 sugar mills for the 2006-15 periods and applies the criterion proposed by Ray to classify them as small, large, or ambiguous. Empirical results suggest that only 8% of the Sugar mills are operating at the MPSS. Key findings are that 47% of mills are running at decreasing returns to scale while 34% are at increasing returns to scale.

Paper ID: P145
Author(s): Tihomir Hunjak and Tomislav Bogović
Title: **Measuring governance efficiency in Croatian cities**

Abstract: In general, the citizens estimate the efficiency of their city governance through the achievement of the goals that the city management promised to achieve for a certain period of time. By enabling relative efficiency measurement of city management, the DEA

method can help in answering if a too high price was paid in reaching those goals and whether the public money was spent in accordance with the 'best value for money' principle. This paper shows the results of the research on governance efficiency in 16 Croatian cities of similar size. The biggest Croatian cities were not included in this research because of their big deviation in population size in relation to the included cities. We identified the set of indicators that describe the resources available to the city management and those that show the outcomes of the governance processes as well as their impact on the development city goals. We present the data of the repeated research and the analysis of the perceived differences in relation to the primary research. Based on these results we bring recommendations for the improvements in the governance practices within the authors' local community.

Paper ID: P148
Author(s): Muhammad Omer Chaudhry and Firdous Kousar
Title: **An efficiency analysis of small scale industrial units: A case study of power looms in Multan (Pakistan)**

Abstract: The number of small scale industries in Pakistan has grown many folds during last few years and so is their contribution in GDP. The government is also facilitating the establishment of small business by providing loans, technical assistance etc. to the small entrepreneurs. Even with the expansion in number, this sector is still not able to achieve a sizable share in the GDP. This is may be due to lack of technical skill, less access to capital, lack of education and other infrastructure facilities. This provides a solid reason to investigate the sources of inefficiency of these small scale units. This study aims to measure the efficiency of these power looms in Multan city with the help of two-stage DEA. This study is one of the pioneer studies in said are in Pakistan. The data is collected from 150 owners of power looms. In the first stage input oriented DEA is employed using inputs like cost of labour, capital, raw material and energy and total production and revenue / profit as output. In the second stage using truncated regression efficiency scores are regressed on exogenous variables like owners' age, experience, education level, age of machinery and ownership structure.

Paper ID: P149
Author(s): Juan Aparicio and Magdalena Kapelko
Title: **Accounting for slacks to measure dynamic inefficiency in data envelopment analysis**

Abstract: Slacks that arise when constructing technologies non-parametrically using data envelopment analysis (DEA) are important because they can be an important source of technical inefficiency. This paper extends the measurement of dynamic inefficiency in the adjustment cost framework to account for slacks. In particular, the paper develops the dynamic weighted additive model in DEA and shows its main properties. Additionally, the approach is illustrated by means of a real application. The empirical application concerns the data on large firms in the dairy manufacturing industry in the main dairy producing countries in the European Union (France, Germany, Italy, Spain, Poland and Czech Republic) over the period 2005-2012. The results show the differences in average dynamic inefficiency between the analysed countries. The findings also indicate that, regardless of the country, firms are, on average, closer to own-country frontier than to the common frontier composed of all firms in the sample. Also, more inefficiency is found, on average, in the new approach as compared to the dynamic framework that does not take into account slacks.

Paper ID: P150
Author(s): Rolf Fare, Shawna Grosskopf and Daniel Primont
Title: **Circularity of the Malmquist productivity index revisited**

Abstract: Circularity is a desirable property for many economic indexes. The Malmquist productivity index, as defined by Caves Christensen and Diewert (1982), does not satisfy the circularity test if technological progress is not Hicks neutral. This negative result was established by Fare and Grosskopf (1996). A number of papers have attempted to remedy this shortcoming. For example, Pastor and Lovell (2005) and Oh (2010) advocate the use of a 'global' Malmquist productivity index which does exhibit circularity by including the entire history of data in the reference technology. This results in requiring that the whole history of productivity indexes be recomputed every time new data is added. In a subsequent approach Lovell and Pastor (2007) introduce `a weakened time-neutrality condition' for the

Malmquist productivity index that results in the index satisfying circularity, equality and base period independence. This requires restricting the `domain over which time-neutrality must be satisfied'. In this paper we review and critically evaluate these efforts.

Paper ID: P151
Author(s): Mojtaba Ghiyasi
Title: **Extended assignment and transportation problems based on DEA models**

Abstract: Assignment problem and transportation problem are two interesting classical problems in operation research literature. The goal in assignment problem is assigning people to tasks and the main goal of the transportation problem is transporting goods from a group of supply centres, called source to a group of receiving centres called destination, in an optimal way. However, in real application there exist not only multiple source of costs but also multiple source of revenue. Used inputs that are usually costly and produced output that are usually beneficial should be considered in the assignment problem. In this paper we propose a model that extends the classical assignment and transportation problems that consider multiple inputs and multiple outputs. A comparison between proposed models and existing models in the literature is provided. We also provide numerical examples and empirical study to illustrate proposed models.

Paper ID: P152
Author(s): Fazıl Gökgöz and Mustafa Taylan Güvercin
Title: **Investigating the super-efficiency of the top ICT companies worldwide**

Abstract: Information and communication technologies (ICT) continuously transforms the socio-economic landscape, changing not only the interpersonal relationships but also the way the other industries do business. While ICT triggers productivity gains in other industries, how does the industry itself progress in terms of productivity? This study aims to investigate the super-efficiency of the top ICT companies worldwide for the period between 2005 and 2015, by employing sequential data envelopment analysis (DEA). Over the last decades, the forces of convergence have blurred the boundaries of the ICT industry, where the nature of the competition became vaguer than before. The study provides comparative analyses on

the super-efficiency of different segments of ICT, where segmentation is based on Martin Fransman's multi-layered new ICT ecosystem model (2010). Our results display that, on average, layer 3 companies (platforms, e-commerce, content and software) are the leaders of super-efficiency within the ICT industry in the recent years, followed by layer 1 (networked elements). In contrast, layer 2 companies (network operators) have lower average super--efficiency scores than the other layers.

Paper ID: P153
Author(s): Fazıl Gökgöz and Mustafa Taylan Güvercin
Title: **Performance benchmark of the top telecom operators in the mobile Era**

Abstract: Telecom operators play the dominant role in making the investments to develop the network on which information and communications technologies (ICT) industry depends. Indeed, this dominance is clearly visible in the revenue, total assets and capital expenditure volumes of the operators are compared with the other segments of the ICT industry. In 2000s, telecom industry experienced two main transformations. In the first half of the decade, voice calls shifted from wire to mobile, whereas in the second half Internet followed the same path. This study investigates the effect of these two transformations on the productivity of the telecom operators at firm level. Sequential Malmquist index method, which is based on DEA, is utilized to calculate the productivity scores of the top telecom operators worldwide between 2000 and 2010. Our results show that the first transformation has a higher average productivity impact on the telecom operators than the second one. Productivity comparisons based on the geographical regions are also presented in the study.

Paper ID: P154
Author(s): Walid Abdelfattah
Title: **Supply chains DEA efficiency: Incorporation of decision makers' preferences**

Abstract: Among many applications, several studies using data envelopment analysis DEA have examined and studied the efficiency measurement of supply chains. However, the majority of the existing approaches dealing with this research area have ignored to take into account an important attribute, which is the preferences of decision makers. The main objective of this research is to

provide consistent DEA models allowing conducting an efficiency analysis to determine the optimal allocation of resources according to these preferences. The idea here is to provide a geometric decomposition of preferences attribution, this idea is especially inspired because a decision maker may treat each supply chain as a single non-detachable entity (horizontal attribution of preferences), or the case when that decision maker considers supply chains detachable (vertical attribution of preferences), or also, the case that combines the two previous situations (combined attribution of preferences). The main interests that can be given to these different ways of considering preferences of decision makers could be summarized in controlling the sample size, and in assisting in sensitivity analysis.

Paper ID: P155
Author(s): Eduard Nezinsky and Mikulas Luptacik
Title: **Measuring income inequalities beyond Gini coefficient**

Abstract: Growing interest in the analysis of interrelationships between income distribution and economic growth has recently stimulated new theoretical as well as empirical research. Since existing theoretical models propose inequality is detrimental to growth, while others point at income inequality as an essential determinant supporting economic growth. The mechanisms linking inequality and growth have also been addressed in empirical literature, e.g. Campano – Salvatore (2006). Measures such as head-count ratio for poverty index or widely used Gini coefficient are aggregated indicators without deeper insight into income distribution among the poor or the households. To derive an indicator accounting for income distribution among the income groups, we propose output oriented DEA model with inputs equal unit and weights restrictions imposed so as to favour higher income share in lower quantiles. We demonstrate the merit of this approach on the quintile income breakdown data of the European countries. Countries with the same Gini index – e.g. Sweden and Finland – can thus be distinguished by the new proposed indicator with respect to the Rawlsian prioritizing lower income groups´ welfare.

Paper ID: P156
Author(s): Dimitris Despotis, Gregory Koronakos and Dimitris Sotiros
Title: **Restatement of different network DEA methods in a common modelling framework**

Abstract: Network DEA is an extension of conventional DEA developed to take into account the internal structure of the decision-making units (DMUs). In network DEA, the DMU is considered as a network of interconnected sub-processes, with the connections indicating the flow of intermediate measures. In this paper, we restate some of the basic network DEA methods in a common modelling framework. We show that independent assessment approach, the leader-follower paradigm, the multiplicative and the additive decomposition methods as well as the recently introduced "weak-link" approach can all be modelled in a multi-objective programming framework and differ only in the solution method that they adopt. Such a common modelling framework makes the direct comparison of the different methods possible and enables us to spot and underline their pros 'n' cons effectively. We illustrate graphically the way by which the aforementioned methods locate their optimal solutions with an example taken from the literature.

Paper ID: P158
Author(s): Pontus Mattsson, Christian Andersson, Fredrik Bonander and Jonas Månsson
Title: **A bootstrapped Malmquist index applied on Swedish district courts**

Abstract: The Swedish district courts have been reformed during more than 20 years and there are recent indications that productivity has declined, e.g. the case goals were not reached for 17% of the criminal cases and 35 % of the civil cases. However, a problem is that productivity is measured by partial measures that ignore substitution between inputs. This study measures total factor productivity (TFP) for the Swedish district courts from 2012 to 2015 by applying data envelopment analysis approach to calculate the bootstrapped Malmquist productivity index of the 48 existing Swedish district courts. In contrast to international research on court productivity, the Malmquist index is fully decomposed. Preliminary results, for 2012-2013, show a substantial variation in TFP change. 20 courts have significantly negative TFP change and 20 courts significantly positive. Decomposed, pure technical efficiency change is +0.4 %, change in scale efficiency is +2.6 %, pure change in technology is +0.9 % and changes of scale of the technology is -2.4 %. A tentative policy recommendation is that courts with negative TFP change could learn from others.

Paper ID: P159
Author(s): Alireza Khoshroo, Mohammad Izadikhah, Ali Emrouznejad and Tahere Jowkar
Title: **Improving energy efficiency in chickpea production in Iran: A data envelopment analysis approach with undesirable output**

Abstract: Modern chickpea production methods require high amount of energy which leads to environmental emissions. Efficient and optimum use of energy inputs is a necessary step towards sustainable crop production. This study mainly focuses on optimizing energy use in chickpea farms of Iran by decreasing excessive use of energy. For assessing the efficiency of chickpea farms in different climates of Iran, 4 inputs including labour, machinery, seed and fertilizers were considered. The outputs consisted of chickpea yield as a desirable output and greenhouse gas emission as an undesirable output. In this paper, a new non-radial DEA based efficiency model by considering undesirable outputs was proposed. The new models were applied for evaluating the efficiency of chickpea production in 16 provinces of Iran. This case study demonstrated the efficacy of our proposed models. Also, the target inputs and outputs and reduction of greenhouse gas emission were determined for chickpea production in each province.

Paper ID: P160
Author(s): Haochen Guo
Title: **An MADM-based method to evaluate the cargo insurance products**

Abstract: Exporting and importing helps grow national economics and expands the global market. Cargo insurance provides coverage against physical damages or loss of goods during shipping, which plays an important role in doing such economic activities. Since there are various companies providing such services with different offers, selecting the best company product can be considered as a MADM problem. The goal of the paper considering criterion which selected (including premium, all risk, experience and financial capability) to utilizes approaches (such as DEA, TOPOSIS and ELECTRE) in order to choose the most preferable company product.

Paper ID: P161
Author(s): Adel Hatami-Marbini
Title: **Network DEA with common weights**

Abstract: Data envelopment analysis (DEA) generally includes two properties. First, DEA is based upon the overall efficiency without observing the internal structure of a production system. Second, a multiplier DEA model allows a production system to select input and output weights in a total flexible way. However, it is essential to deal with these two properties in reality. This paper presents a common-weights DEA model where the internal structure of a production system is known. We also present a numerical example to exemplify the applicability of the proposed model in this research.

Paper ID: P162
Author(s): Subhash Ray, Kankana Mukherjee and Abhiman Das
Title: **Financial deregulation, efficiency and productivity dynamics of Indian banks**

Abstract: In the early 1990s, India instituted major financial sector reforms to improve the efficiency, productivity and profitability of Indian banks. While empirical research on Indian banks performance has grown manifold during last two decades, there is not a single study which has comprehensively examined the efficiency and productivity dynamics over the entire liberalization period 1992-2016. Additionally, empirical research has paid very little attention to the post-2008 financial stability issues. In this context, this paper examines the historical trajectory of efficiency and productivity dynamics of Indian banks post deregulation using directional distance function approach incorporating non-performing loans as an undesirable output. We modify and extend the directional distance function model to measure TFP change. Empirical results show that ownership still plays a dominant role in performance of Indian banks. However, the performance gap between state-owned and private banks has narrowed down post 2008. Non-performing loans is not just posing a threat to financial stability, it is a major constraining factor affecting efficiency and productivity growth of Indian banks.

Paper ID: P163
Author(s): Subhash Ray and Shilpa Sethia
Title: **Efficiency benchmarking of power generation utilities in India for assessing the opportunity cost of pollution reduction**

Abstract: This study assesses the performance of thermal power generation companies in the major Indian states, treating good and bad outputs as jointly disposable. The paper uses utility level data to measure efficiency using directional distance function. The technology is assumed to exhibit variable returns to scale. The non-linear model has been linearized. The model considers one good output (generation), one bad output (emission), two polluting inputs (coal and oil) and one neutral input (installed capacity). The preliminary results from the analysis of 59 power plants for the year 2005-06, identify several power plants as sub-optimal, leaving a potential for emission reduction and reduction in the use of fuel along with a possible rise in power generation. It emerges that the average level of inefficiency is about 10%. However, there are some plants that exhibit improvement potential of up to 70%, they need to be further investigated.

Paper ID: P164
Author(s): Mrinal Dasgupta and Deepankar Sinha
Title: **Pricing of port services in Indian major ports: A DEA based approach**

Abstract: The pricing of services by major ports of India are guided by regulations led down by the tariff authority of major ports (TAMP). TAMP has so far made several changes in its guidelines starting from cost plus recovery methods to flexible pricing with ceiling limited to WPI adjusted tariff rates. In spite of its effort to orient its policies to prevailing economic conditions, TAMP has been severely criticized from all corners. A recent study initiated by the government of India namely the NTPDC (2014) also recommend change in TAMP guidelines. In this paper an attempt has been made to use DEA based approach to price its services. The approach suggests identification of the desired output based on inputs deployed in a port and its competitive environment to set the tariff. Results show that this approach not only leads to flexibility in pricing mechanism in ports but also enable it to retain its competitiveness.

Paper ID: P165
Author(s): Trishit Bandyopadhyay
Title: **Measuring the scoring efficiency of a soccer match: A case study of Indian Super League**

Abstract: Data envelopment analysis (DEA) has been used to assess efficiency in various areas including sports. DEA has application in sports such as basketball, baseball, soccer and so on. In this study the efficiency of soccer teams taking part in Indian Super League (ISL) is estimated using DEA framework. It is based on the work of Villa and Lozano published in 2016 (EJOR 255, 559-569) which presents a novel approach to measure the scoring efficiency of football teams in a match,- where both the attacking and defending variables of the two teams are used in a parallel process network DEA model. The method is applied to the recently founded Indian Super League tournament,- which has been growing in popularity in India since its inception three years ago. The results show that the efficiency of teams thus found does not always correspond to their rankings, often top-spots, in the super league tournament. Later, Villa and Lozano's approach is attempted to be extended by splitting the match into two halves and from there the efficiency of the two teams is estimated. The scoring efficiency of the teams across matches is averaged to obtain a team's scoring efficiency for the entire tournament.

Paper ID: P167
Author(s): Sanjeet Singh and Prabhat Ranjan
Title: **Efficiency analysis of higher education institutions: Use of categorical variables**

Abstract: This paper applies DEA to evaluate enrolment efficiency of colleges in Bihar, one of the largest states of India. Proposed study includes colleges funded and managed through seven state public universities. To follow homogeneity condition of DEA, colleges providing courses of arts (languages and humanities only), science, and commerce only have been selected. Colleges, providing technical and professional courses such as, engineering, medical, education, law, agriculture, etc., have been excluded. Numbers of students enrolled in undergraduate and post graduate courses are considered as two outputs. Numbers of teaching and non-teaching staff are considered as inputs. Colleges have been classified into two categories based on their presence in rural or urban area. The efficiency of a college due to

any categorical value is calculated as the ratio of overall efficiency and efficiency calculated with similar categorical DMUs only. Impacts of both categorical variables, affiliation to university and geographical presence, have been analysed through various approaches such as, average efficiency of DMUs due to a categorical value, and second stage regression analysis.

Paper ID: P168
Author(s): Raheleh Jalili, Alireza Vahidi and Abdolsadeh Neisy
Title: **DEA-Risk efficiency of Banks Indices**

Abstract: This paper deals with the performance evaluation of Iranian banks in the presence of risk measure which is an inevitable indicator in the banking industry. It utilizes data envelopment analysis (DEA) methodology which can consider various risk measures and functionals including semi-variance, value at risk (VaR), and conditional value at risk (CVaR). The main aim of this study is to assess the DEA-risk efficiency of 10 banks in Iran with two risk measures, VaR and CVaR, as well as to perform the sensitivity analysis of obtained results.

Paper ID: P169
Author(s): Ali Mirsalehi and Hamid Nilsaz Dezfouli
Title: **Centralized resource allocation models in a unified framework**

Abstract: The present study demonstrates a method for linking radial and non-radial centralized resource allocation (CRA) models in a unified framework and develops such models to a more general case. The proposed model contains a few scalar parameters. Also it is possible to relocate the analysis in any areas between radial and non-radial CRA models through manipulating the amount of the parameters. A suitable choice of such parameters, several of the frequently used CRA models (e.g., the CRA-BCC, CRA-ERM and CRA-SBM models) are taken from it. This model is flexible sufficient for the central decision-maker to regulate the inputs and outputs to attain contraction of aggregate input consumption as well as the expansion of aggregate output generation and will resolve an issue in which the decision maker does not similarly prefer the efficient units.

Paper ID: P172
Author(s): Osman Zaim
Title: **Measuring energy intensity in U.S manufacturing: A new approach**

Abstract: In multilateral comparisons of environmental performance over time, "real" energy intensity computed either by index decomposition approach or structural decomposition approach are most commonly used measures. While their intuitiveness and computational ease make these indices attractive, their time series properties create considerable challenges in performing informative and fair comparisons. Furthermore, the resultant measure of energy intensity in these studies, is still the inverse of a partial factor productivity measure (PFP), that ignore the type of substitution among inputs and hence, make it a measure that disguises rather than illuminates. The theoretical part of this paper shows how one can overcome the shortcomings of the energy intensity measure by constructing a new energy index using directional technology distance functions. The new index constructed in this study not only overcomes the shortcomings of the energy intensity measures but also satisfies the axiomatic properties of index numbers that are laid down by Fisher. An empirical application on U.S. State level manufacturing sectors further complements existing studies.

Paper ID: P173
Author(s): Jiyoung Lee, Chulyeon Kim and Gyunghyun Choi
Title: **Exploring the quantum-jump benchmarks using frontier relaxation approach in DEA**

Abstract: DEA is a useful tool for benchmarking based on the efficiency evaluation of decision making units (DMU). Within the DEA process, benchmarks are selected from efficient DMUs located at the boundary of the production possibility set (PPS) called 'frontier'. However, the process has a limit that DMUs cannot capture the opportunity of discovering the benchmark outside of the PPS where significant efficiency improvements can be made. In other words, frontiers can be regarded as constraints to limit the search space of finding better benchmarks. To overcome this limitation, this study proposes a new benchmark selection method with expanded search space that is not limited to PPS under the variable returns to scale (VRS) assumption. Specifically, an expansion of search space is possible by implementing the relaxation of frontiers. In addition, the benchmarking target produced by

this method provides further improving direction for efficient units which were not derived from previous approach. This approach provides new opportunities for DEA-based benchmarking to extend applications.

Paper ID: P175
Author(s): Jing Fu
Title: **Facilitating Sino-Japan clean air collaboration: An application of clustering two--stage data envelopment analysis with undesirable intermediate measures**

Abstract: Air pollution continues to pose a major threat to human health in China and its neighbour countries including Japan. This paper proposes potential clean air collaboration between China and Japan featuring clean coal technology. Although the general clean air trend in China is to replace older coal-fired generation with non-fossil fuel generation, technologies of gas cleaning and to effectively use coal ash in Japan could play an important role to achieve dramatic air quality improvement in a short term. In order to recognize the target regions, air pollution improvement efficiencies in China (2005-2014) are evaluated and compared to that of Japan by clustering two-stage data envelopment analysis (DEA) with undesirable intermediate measures. Then we analyse the mutual interests and costs in form of technology transfer and regulation sharing by a multi-criteria allocation game. Most application studies utilizing DEA stop at the evaluation stage, and only show the output/ input--oriented amount to be increased or decreased. Our systematic analysis provides an economical and environmental motivation for a cooperative solution between China and Japan.

Paper ID: P176
Author(s): Matthias Klumpp
Title: **DEA Malmquist index application for university ranking data**

Abstract: As lately university rankings are evolving over time and with a stable evaluation scheme, dynamic analysis becomes more interesting. Similarly, efficiency analyses are increasingly determined by longitudinal comparative approaches. This paper applies Times Higher Education and Leiden Ranking data combined with ETER input data (budget, staff) for 70 European universities in the timeframe 2012-2014 for a DEA Malmquist index efficiency

calculation. Dynamic efficiency improvements are unevenly distributed among institutions and are in total higher than expected. Research and policy implications include the notion to focus more on comparative time series development of institutions than on static analyses as done in the past - e.g. for funding and excellence evaluations.

Paper ID: P177
Author(s): Vladimir Krivonozhko and Andrey Lychev
Title: **Algorithms for FDH frontier visualization**

Abstract: Free disposal hull (FDH) model introduced by Deprins, Simar and Tulkens (1984) expanded the DEA models by relaxing the convexity assumption. In the DEA scientific literature, many papers were devoted to development of solution methods for computations of various scale characteristics in FDH models. These methods are divided into two groups. In the first group, methods are based on mathematical programming (MP) approach. The second group of methods involved enumeration methods. However, as Cesaroni, Kerstens and Van de Woestyne (2016) noted, very few papers were devoted to methods for FDH frontier reconstruction. In this paper, we propose two groups of methods for FDH frontier visualization. They are based on two approaches mentioned above. Every approach possesses its own advantages. In our work we present and describe peculiarities and advantages of every approach. Our theoretical results are confirmed by computational experiments using real-life data sets from different areas.

Paper ID: P178
Author(s): Sara Fanati Rashidi
Title: **Determination of right/left return to scale in two-stage processes based on dual simplex**

Abstract: As a non-parametric method of relative efficient measurement of a group of decision making units (DMUs) data envelopment analysis (DEA) is one of the most important tools in efficiency computation. One of the main concerns dealt with in DEA is dealing with two-stage processes in which, produced outputs of the first stage inputs are used as inputs for the second stage. The outputs of the first stage are considered as the intermediate products.

Therefore, the second stage uses these intermediate products for producing the outputs of the same stage. Based on this construction, the total process can be analysed for efficiency production from two sub-processes. In this paper, a new model is proposed that eliminates the defections of the previous models and is used to determine the right and left return to scale in two-stage processes of decision making units.

Paper ID: P181
Author(s): Laura Carosi, Giovanna D'Inverno, Giulia Romano and Andrea Guerrini
Title: **Estimating efficiency of Italian water utilities by accounting for quality issues**

Abstract: This paper compares efficiency of Italian water utilities and includes in efficiency assessments both quantity and quality variables. Unaccounted-for water and environmental impact, measured as environmental infringements made by municipalities served, are included in the estimation as undesirable outputs. The determinants of performance trends are then assessed, by linking the specific features of each firm (such as ownership, size, geographical location and degree of diversification) to the trend of its efficiency.

Paper ID: P184
Author(s): Antonio Peyrache
Title: **Homothetic nonparametric production frontiers**

Abstract: Homotheticity and Hicks neutrality plays a central role in economic theory and index numbers theory. For example, under the joint satisfaction of homotheticity and Hicks neutrality, it is possible to show that many known total factor productivity (TFP) index numbers are the same. Moreover, under these assumptions, TFP indexes satisfy the transitivity test (see Peyrache, 2013); this means that it is possible to make multilateral transitivity comparisons. In this paper a method is proposed which allows estimation of inefficiency scores under the assumption of homotheticity or/and Hicks neutrality. The method is sufficiently general to allow for multi-input and multi-output technologies; and it is also simple to understand and computationally fast. A Monte Carlo is provided to show that the estimator is effective in reducing the curse of dimensionality associated with nonparametric frontier methods.

Paper ID: P186
Author(s): Miroslav Hužvár and Mária Grausová
Title: **Efficiency of health systems in European countries assessed with DEA**

Abstract: A few studies comparing the efficiency of national health systems based on DEA have been published yet. They use different approaches to capture the production technology of health systems by DEA models. However, some significant drawbacks can be generally observed. Besides the natural heterogeneity of health systems, the crucial difficulty of the research lies in the fact that health outcomes are influenced by a large number of factors that are not under control of health systems and their impact may be rather different in individual countries. It implies that the assessment of health system efficiency should be considered in the wider socio-economic and environmental context. In order to reduce the impact of exogenous factors on the efficiency scores we divide the European countries into groups based on their social conditions and economic power of the citizens. Then we design a DEA model to assess efficiency of national health systems within each of these groups.

Paper ID: P187
Author(s): Antonio Peyrache and Maria Silva
Title: **Multi-level parallel network models**

Abstract: We define a multi-level parallel network system as one where there are multiple layers of decision (e.g. government allocating resources to hospitals, that need to allocate resources to departments/services, that use these resources to undertake their normal activities), and where the production of outputs at the lowest level of decision happens concurrently rather than sequentially. Since decision making occurs at different levels it is important to develop models that (i) that into account the multi-level structure of decision making opening the black box; (ii) assess the efficiency of all levels in a coherent way; and (iii) provide guidelines on the efficient allocation of resources in all levels of decision. This paper reconciles previous literature on the topic, points to some existing problems of standard approaches, and suggests new models of analysis decomposing an industry score into firm inefficiencies, department inefficiencies and re-allocation inefficiencies. An example with real hospital data is used to illustrate the approach.

Paper ID: P188
Author(s): Simona Alfiero, Alfredo Esposito, Parisa Madhooshiarzanag and Mehdi Toloo
Title: **The efficiency measures of the European commercial banking sector: A relational network DEA application**

Abstract: The data envelopment analysis (DEA) is a widely applied methodology to evaluate the relative efficiency of a decision making units with multiple inputs and multiple outputs. The BCC model decomposes the overall efficiency into the product of scale efficiency and technical efficiency. Through the decades it was applied to diverse sectors being the banking sector among the most practiced. The conceptual idea that the decomposition of the production process could be able to provide insights of inefficiency sources led to the development of many Network DEA (NDEA) models. The underlined idea was that by computing the efficiencies of the two sub-processes was possible to recognize the inefficiency sources of the entire structure. The need to evaluate a recent efficiency measure of UE banks is at the core of our study while contributing to a reliable evaluation relying on a large sample of first-tier European commercial banks. To obtain a consistent efficiency measurement results, the integration of factors in a two-stage approach allows for insights on the banks processes of production and profitability.

Paper ID: P189
Author(s): Francisco Daladier Marques Júnior, Kelvin Lopes Dias, Paulo Roberto Freire Cunha and Marco Antônio de Oliveira Domingues
Title: **A multi-objective way to select the best settings using super-efficiency SBM DEA models to deliver network virtualization services: A stochastic case of study**

Abstract: This paper brings a new way to choose the most efficient settings to deliver virtual network services. In measurements were used type 2 hypervisors running Virtual Machines with a lightweight virtualization called container-based virtualization. To assembly of the environments were used 5 Linux's distributions, as well as the emulated network interfaces by hypervisors, besides the container-based tools Docker and LXC. The experiments followed the IETF experimentation's methodology named RFC of numbers 2544 and 6815. The assessments were performed using TCP/IP's protocols on Layers 2 and 3. The stochastic processes referring to the virtualized traffic point out to long-range dependence, that it has memory,

it is contagious, and causes high variability, i.e. irregular to deliver of services, bringing the Self-Similarity's (SS) concept. Confidence Intervals (CI) for the mean and variance, and Hurst's parameters (SS's measure) were used to form the Objective Functions (OF). It were evaluated 50 DMUs, where Super-efficiency SBM DEA models were used to select the most efficient settings, as well as seek to minimize SS's effects. The results have quite similar behaviour with or without CI.

Paper ID: P190
Author(s): Ayşe Çoban, Orhan Çoban and Duygu Baysal Kurt
Title: **Technical and scale efficiency of the Turkish automotive industry using data envelopment analysis**

Abstract: The first assembly production experiment in the Turkish automotive industry, which dates back to the beginning of the 20th century, was made by Ford Motor Istanbul in 1929. The Turkish automotive industry, which produced a total of 10,000 vehicles in the 1960s, has reached 1.8 million vehicle production capacities today. According to the data of the year 2015, approximately 50000 people are employed in the Turkish automotive main industry, 1.5 million vehicles are produced and about 1 million of these vehicles are exported. The export revenue of the industry is about 14 billion dollars. The aim of this study is to analyse the economic performance of the Turkish automotive industry on the firm and industry scale. In the analyses, 14 companies operating in the automotive main industry were taken from dictation and the data set was obtained from OSD (The Automotive Manufacturers Association). Efficiency and technical efficiency indices were used in determining economic performance. Data envelopment analysis was used to measure technical efficiency while labour productivity was the basis for calculating efficiency indices.

Paper ID: P191
Author(s): Giannis Karagiannis
Title: **Pure output and pure input DEA models: A tour de force**

Abstract: In this paper we review DEA models without outputs or inputs and models with a single constant input or output and we explore their properties and relations. Then we summarize their potential usefulness in several applications, including (a) multiple criteria decision-making (MCDM) such as supplier selection and ABC inventory classification, (b) construction of composite indicators (environmental, sustainability, subjective well being, etc.), (c) ratio analysis and (d) spatial efficiency. We further consider the cases of optimistic versus pessimistic composite indicators and of intra- and inter-group composite indicators. We also explore the usefulness of these models in other topics of performance evaluation such as cross efficiency, efficiency based on common weights, and productivity analysis. Lastly, we consider their aggregation across DMUs rules.

Paper ID: P192
Author(s): Mona Alibeik and Mohsen Rostamy Malkhalifeh
Title: **A novel optimal method for calculating the Malmquist productivity change index**

Abstract: Malmquist productivity index (MPI) has always been noticed by economic analysts in estimating productivity growth. Each of the indicators that have been presented so far has advantages and disadvantages, for example the geometric mean form of the contemporaneous MPI is not circular and linear programming techniques which are used to compute and decompose the index may suffer from infeasibility issue. The global and Meta MPI satisfy circularity and those are immune to LP infeasibility but both of them need to be recomputed when a new time period is added to the data set. Also the biennial index does not have these problems but in the past three methods there is a common problem, some of the points on the boundary was made from the convex combination of two other units in two different times. We cope with this issue and introduce a new MPI involving several attractive features: it is circular; it is always feasible; it does not need to be recalculated when a new time period is added to the data set and it significantly reduces the required computational burden. A numerical example (a panel of 93 US electricity generating firms in four years) is provided to validate our new approach.

Paper ID: P193
Author(s): Atakelty Hailu
Title: **Bad outputs in DEA models: Clearing some confusions**

Abstract: Undesirable or bad outputs have been incorporated into efficiency and productivity analysis using parametric methods and data envelopment analysis (DEA) models. There has been very little controversy in how bads are modelled using the former. In the case of DEA models, on the other hand, there have been some competing approaches and this has caused some controversy in the literature. Given the popularity of DEA, it is important to evaluate critically the alternative approaches and identify their pros and cons. This paper describes and evaluates the two major competing formulations – the weak disposability formulation and the so-called 'bads as inputs' approach. These are compared in terms of their power to discriminate among observations based on performance, the properties of the nonparametric technology sets, the capacity to represent the underlying technology adequately and suitability for estimating the opportunity costs of abatement or regulatory burden. Simulated results showing how the different models perform as sample and output vector sizes vary are also presented.

Paper ID: P195
Author(s): Thanasis Bouzidis and Giannis Karagiannis
Title: **Output interdependency in network DEA**

Abstract: The purpose of this paper is to accommodate the proportional output reduction approach that can take account of the output interdependency into the network DEA model. Our point of departure is a serial two-stage structure where the output from the first stage is the only input to the second stage (i.e., single intermediate product). It is also assumed that there is output interdependency only at the second stage. First, we will examine the implication of output interdependency on a well-known result in the conventional two-stage model with a single intermediate product, namely that the system efficiency is the product of the two stages' efficiencies, which are estimated by applying the conventional DEA model on each stage separately. Our main research question is whether this unique system efficiency decomposition into its divisional efficiencies still holds after adjusting both the system and the second stage biased efficiency scores for the fixed-sum nature of the final output and

if not, what is their relationship. To this end, we use match-level data concerning the Greek football clubs participated in the 2013-14 premier league to examine empirically the above implications.

Paper ID: P197
Author(s): Yuri Fedotov, Nikolai Hovanov and Kazimir Iablonskii
Title: **DEA models with undesirable inputs and outputs: Application of power normalization over the spread of variables in a sample**

Abstract: DEA efficiency estimation relies on assumption of desirability of the unit's inputs/outputs. It claims monotonicity of binary relation comparing technical efficiency of input-output vectors which means that for any two different input-output vectors (x,y) and (x*,y*), such that x=(x1,…,xn) << x*=(x1*,…,xn*) and y=(y1,…,ym) >> y*=(y1*,…,ym*) holds (x,y) ≽ (x*,y*), where "≽" – a binary relation "more efficient" determined for input-output vectors; "<<" – a binary relation "not larger than" for inputs; ">>" – a binary relation "not smaller than" for outputs; n – number of inputs; m – number of outputs. Thus, for any two different plans (x,y) and (x*,y*), (x,y) ≽ (x*,y*) if and only if (–x,y) >> (-x*,y*). As DEA work with finite number of units we can transform all input-output variables with power normalization. Normalization of variable is based on the spread of its observed values determined by max and min values in a sample. It ensures "the more the better" property for desirables, while undesirables are transformed according to "the less the better" rule. Thus, all normalized variables get non-negative values, do not exceed one and guarantee the monotonicity of efficiency relation.

Paper ID: P200
Author(s): Panagiotis Zervopoulos, Ali Emrouznejad and Sokratis Sklavos
Title: **A Bayesian approach for correcting bias of DEA efficiency and super-efficiency estimators**

Abstract: This work presents a Bayesian method for correcting bias of efficiency and super--efficiency estimators. The new method allows for finite-sample inferences on efficiency and super-efficiency scores. In the extant literature, the most widely used method for correcting

bias of efficiency estimators is the DEA bootstrap; however, this method has major limitations, including the asymptotic justification and the ambiguity of the obtained bias-corrected efficiency estimators due to their significantly large and overlapping confidence intervals. This study presents a Bayesian approach organized around formal statistical analysis, proofs and simulations. This new approach takes into account the dependence between efficiencies and super-efficiencies, which applies when finite samples are present, for estimating bias--corrected scores. The efficiency and super-efficiency estimators obtained from this Bayesian approach are consistent.

Paper ID: P201
Author(s): Vladimír Holý and Karel Šafr
Title: **Comparing R&D efficiency of European countries using robust DEA**

Abstract: We analyse the efficiency of research and development (R&D) of European countries by constructing a robust data envelopment analysis (DEA) model. R&D expenditure, private investments, number of researchers, number of patents, number of scientific publications and turnover from innovations are considered as DEA inputs and outputs. We also cluster the countries based on overall efficiency and specialized efficiencies for a single output with multiple inputs and a single input with multiple outputs. The main data source is EUROSTAT while bibliometrics are retrieved from other sources.

Paper ID: P202
Author(s): Steffen Hoffmann, Andreas Kleine and Andreas Dellnitz
Title: **Selecting data and DEA results for visualization**

Abstract: The major advantage of DEA is to reduce multivariate data to a single key performance indicator (KPI). However, this KPI is just one element to determine the (economic) situation of a decision making unit (DMU). Beside this, DEA offers more information about the DMU under consideration; more precisely: optimal multiplier weights, reference sets, returns to scale, etc. The purpose of this contribution is to identify similarities or dissimilarities within the set of DMUs in a dynamic context, applying the aforementioned DEA results.

Therefore, multidimensional scaling will be used. But here, the question arises: what data should be selected – regarding the decision situation – at best? In this talk we focus on this question by investigating different combinations of data, i.e., the decomposition of efficiency scores, raw data of DMUs (activities) as well as datasets joining exogenous and endogenous variables. The results are illustrated by numerical examples.

Paper ID: P204
Author(s): Kazimir Iablonskii, Yuri Fedotov and Nikolai Hovanov
Title: **Performance assessment of Saint Petersburg public hospitals with DEA and APIS**

Abstract: The study evaluates the performance of Saint-Petersburg city public hospitals attempting to account for multifaceted nature of their operations. Assessment relies on the Neely's performance prism that assumes multi-input and multi-output description of production process, multidimensional nature of organization's activities and multi-subject evaluation of organizations. The study is devoted to assessment of 47 St. Petersburg public hospitals in the period 2013-2016. Provision of medical services to the citizens is assessed with regard to OMI funds supplied to the hospitals. In addition to the hospitals' technical efficiency assessed for 2 inputs and 2 outputs the model incorporates the views of stakeholder groups, as assumed by the Performance Prism. The inquiry among patients, doctors, nurses and management was undertaken in each hospital and answers were quantified with non-discrete Likert scale presented as two-sided segment. The stakeholders' opinions are used in DEA models. Aggregated Preference Indices System (APIS) approach that allows for multi-criteria assessment of alternatives on the basis of ordinal, non-exact and incomplete data was also applied.

Paper ID: P206
Author(s): Francisco Vargas, Arnulfo Castellano and Luis Rentería
Title: **Optimal propensity to consume, shadow prices and the Great Recession**

Abstract: There exists an optimal marginal propensity to consume (MPC). As two interpretations for optimal MPC have been outlined, the relationship is two-folded. First, in relation to investment and second, in relation to income. In this paper only the relationship with income

will be considered. The optimum is obtained by the shadow price of the household consumption behaviour. It is assumed that in an economic crisis, MPC moves from its optimal level. Therefore, reducing wellbeing. The shadow price should reflect this situation. This paper is an attempt to test whether the former hypothesis is true or false. For such a purpose, data about economic agents´ flow of funds has been compiled for the main world economies. The period comprises the years before, during and after the financial crisis. In addition, consumption patterns are analysed in order to evaluate the impact of deviations from the optimal MPC.

Paper ID: P207
Author(s): Subir Sen
Title: **Relationship between rainfall and foodgrains productivity: Study of selected Indian states**

Abstract: In India land demand is high for industrial and residential purposes, the annual growth rate of area under foodgrains have decreased from 0.29% during the 10th Plan (2002-03 to 2006-07) to 0.19% in the 11th Plan (2007-08 to 2011-12). Weather-related events may impact land use and production especially with higher temperature affecting water availability, seasonal droughts, etc. Under such predicted uncertainties and trends, the demand for food crops and of other allied agricultural services can only be met through improvements in yield. Existing literature on Indian agricultural productivity provides agricultural productivity estimates up to 2004-05. This study provides productivity estimates beyond 2004-05 to 2012-13 for 19 states (18 major Indian states participate in the National Agricultural Insurance Scheme). This study substantiates the importance of irrigation and rainfall for productivity, both considered non-discretionary in nature. We use the theoretical arguments favouring separation of discretionary inputs (fertilisers, pesticides, finance and insurance, etc.) and the non-discretionary inputs while measuring productive efficiency.

Paper ID: P208
Author(s): Alessandro Cortes
Title: **A triple bottom line approach for measuring supply chains sustainability using data envelopment analysis**

Abstract: This paper deals with the issues faced by those who endeavour in measuring sustainability in supply chains (SC) by using a comprehensive approach. Elkington´s Triple Bottom Line (TBL) divides sustainability in three aspects: economic, environmental and social (E2S). Firms report their business (including SC) sustainability impacts through Corporate Sustainability Reports (CSR). According to Global Reporting Initiative (GRI), a CSR framework, reported information should be sufficiently accurate/detailed towards performance, but reports are rather qualitative. Fast fashion (FF) is a recent phenomenon of production/promotion of cheap/readily disposable clothes. Data envelopment analysis (DEA) is the adequate tool to identify best practices regarding sustainability (multidimensional) and supply chains in FF. To allow comparability and tackle lack of quantitative data, we propose a TBL cluster (input, output): for each disclosure a three layers scoring scale: absence (1), qualitative only (2), 2nd layer plus quantitative (4). This work´s main contribution is the use of DEA as a powerful tool to measure sustainability in SC and the TBL clusters link E2S dimensions in an innovative way.

Paper ID: P209
Author(s): Jana Hanclova, Mehdi Toloo, Lukas Melecky and Michaela Stanickova
Title: **Energy efficiency comparison of EU28 countries based on various undesirable outputs of air emissions**

Abstract: This paper presents an assessment and comparison of energy efficiency of EU28 countries in reference period 2008–2014. Cross-country comparison is based on data envelopment analysis (DEA) using directional distance function (DDF). DEA model includes air emissions as undesirable outputs in the various forms (nitrogen oxides, carbon dioxide and particulates smaller than 2.5 or 10). The preliminary findings resulted in rank and evaluation of surveyed European member states by energy efficiency and moreover the paper discusses the influence of different types of air emissions to the level of efficiency.

Paper ID: P210
Author(s): Tripta Thakur and Pavan Khetrapal
Title: **Benchmarking of Indian electricity distribution utilities using data envelopment analysis**

Abstract: This paper presents a framework for evaluating the cost-efficiency of 27 Indian state government distribution utilities. The efficiency evaluation is based on data envelopment analysis (DEA) and the analysis promises to provide a useful tool to the regulating commission for tariff setting and also in future for calculating X-factor for performance based regulation. Separated benchmarks were derived for network cost and transmission and distribution losses acting as separate inputs, while estimated average energy sold (KWh), energy consumed per square km (KWh), Energy consumed per thousand populations (KWh), customers (Million) and distribution line length were chosen as the output variables. Two separate models have been employed for benchmarking with respect to the cost and T&D losses named as Distribution-Cost-DEA (DC-DEA) and T&D-Loss-DEA (T&DL-DEA) model respectively. The results of the study indicate the existence of cost inefficiency; majority of the utilities is not producing at the minimum level of the cost. Utilities are intrinsically inefficient and bound to be mismanaged, and therefore a change of property rights will per se lead to a performance improvement.

Paper ID: P212
Author(s): Sungmook Lim
Title: **Data envelopment analysis with imprecise data based on robust optimization**

Abstract: Conventional DEA models require that inputs and outputs are given as crisp values. Very often, however, some of inputs and outputs are given as imprecise data where they are only known to lie within bounded intervals. While a typical approach to addressing this situation for optimization models such as DEA is to conduct sensitivity analysis, it provides only a limited ex-post measure against the data imprecision. Robust optimization provides a more effective ex-ante measure where the data imprecision is directly incorporated into the model. This study aims to apply robust optimization approach to DEA models with imprecise data. Based upon a recently developed robust optimization framework which allows a flexible adjustment of the level of conservatism, we propose two robust optimization DEA model

formulations with imprecise data; multiplier and envelopment models. We demonstrate that the two models consider different risks regarding imprecise efficiency scores, and that the existing DEA models with imprecise data are special cases of the proposed models.

Paper ID: P214
Author(s): Assem Tharwat, Basma El-Demerdash and Ihab El-Khodary
Title: **Evaluating the performance of European football teams using data envelopment analysis**

Abstract: Today's competition has become intense not only in business but also in sports. Football is one of the most popular sports in the world. In this paper, we evaluate the performance of the 56 teams contesting in the group stage of the Champions League and the knockout phase of the Europa League during the 2014/2015 season. The DEA technique was adopted through measuring the efficiency of the competing teams. The analyses revealed that most teams were efficient given their performance at the domestic and international leagues, while a smaller number was efficient at the international level only.

Paper ID: P215
Author(s): Sohrab Kordrostami and Monireh Jahani Sayyad Noveiri
Title: **The efficiency measurement of multi-period supply chains with undesirable outputs: A DEA-based approach**

Abstract: In real-world applications, there are situations that the performance of supply chains in the presence of undesirable outputs should be evaluated in multiple periods. Therefore, the current paper proposes an approach based on data envelopment analysis (DEA) to evaluate the efficiency of supply chains with undesirable outputs in multiple periods of time. To illustrate, a DEA-based approach is suggested to specify the overall and individual efficiency scores of multi-period supply chains with undesirable outputs. Also, the efficiency of each component of supply chain for each period is estimated. The weak disposability assumption is considered for undesirable outputs. An example is used to illustrate the proposed approach.

Paper ID: P216
Author(s): Sai Amulya and Mukul Kulshrestha
Title: **Productivity growth, technical progress and efficiencies in the Indian urban water supply sector**

Abstract: DEA-based Malmquist approach for evaluating total factor productivity (TFP) and technology change in 21 Indian water supply services over 2005-2010 is employed in this paper to answer the following a. Are Indian water supply services efficient? b. Are water supply operations improving over time? c. How should the present tariffs be restructured in order to overcome losses in the sector? Methodology DEA is employed to estimating relative efficiencies of services. To evaluate efficiency, productivity and technical change over time, Malmquist productivity index is used. Analysis and results Sample mean efficiencies were found to be 45%, with individual municipalities performing as low as 18%. The TFP growth model indicated that over the time-period 2005 to 2010 increasing inefficiencies were witnessed implying further deterioration in services. X-factors calculated from TFP model was found 2.6% for most inefficient municipality indicating that municipality should increase tariffs by 2.6% annually over 5 year period to catch-up nearly 10% of the gap with best-practices to improve annual productivity growths ultimately leading to financial sustainability of the services.

Paper ID: P217
Author(s): Mark Anderson, Rajiv Banker, Yan Ma and Han-Up Park
Title: **Production efficiency in a volatile environment: Evidence from the oil and gas industry**

Abstract: We investigate how the dramatically changing environments during economic crises affect firms' production efficiency in the Canadian oil and gas (O&G) industry that has faced extraordinary challenges during the past fifteen years. We develop a DEA model to measure O&G firm efficiency recognizing the special features of the exploration/development and production activities of 632 upstream firms in Canada over the period 2002-15. This includes 340 firms that did not survive until the end of the sample period because they were acquired, delisted, or in bankruptcy, receivership and liquidation related proceedings. We focus on examining how O&G firms' efficiency changed over time, and, in particular, how the time series were interrupted by the economic crises and corresponding increase in

output price volatility. We document that the shifting market conditions and price volatility significantly and systematically influence O&G firm efficiency in a predictable manner depending on their financial strength and other specific contextual conditions.

Paper ID: P218
Author(s): V. Alpagut Yavuz
Title: **Performance measurement of departments in universities as a basis of policy development**

Abstract: In recent years, the number of higher education institutes increased considerably in Turkey. Various quality standards have been introduced to rank universities periodically. Thus, developing strategies and policies to improve the ranking of the universities has become the top priority at the management level. The achievements of academics in a university depend on their performance in three aspects: research, teaching and service. In terms of research; the number and quality of publications and research projects receive the most attention. However, the amount of time spent for research activities is related to the time spent for teaching and services. In fact, teaching workloads differs greatly among departments due to the nature of subjects taught and the number of registered students. Thus, an assessment methodology is needed encompassing all these conditions in order to truly assess their nature and performance. A DEA is conducted in this study for the performance measurements of departments of a university. The study suggests that, this analysis can be a suitable basis of creating custom research incentive programs for different study areas to improve the research environment.

Paper ID: P219
Author(s): Reza Kargar and Mitra Rezaei
Title: **Finding efficient frontier in DEA with PSO algorithm**

Abstract: Data envelopment analysis (DEA) based on mathematical programming techniques and a non-parametric method to measure the efficiency and performance assessment is a decision-making unit. The performance data DEA for each DMU They are measured in comparison with others. In this paper, we deal with the problem of finding the strong

and weak defining hyperplanes of the PPS. In this method, using geometric properties and using the PSO algorithm is a powerful and efficient solution find weak and strong defining hyperplanes of BCC efficient frontier. The method described in the classification of units and modelling methods will also be useful for inefficient units. In this method, based on the work of independent creation and use of multiple models in the DEA.

Paper ID: P220
Author(s): Reza Kargar and Nooshin Ahmady
Title: **Finding congestion space in DEA with genetic algorithm**

Abstract: Congestion is one of the important and applied topics in DEA because it not only reduces cost, but it also increases output. In this paper, an attempt is made to find congestion space by means of NEW and BCC models. To that end, a fitness model was made to find congestion space with NEW interface, where DMUs are inefficient, and defining hyper planes parallel to output axes were introduced. Then, by calibrating the parameters of genetic algorithms by means of automats, the optimized solutions of the model, which are the normal vectors of defining hyperplanes, were found and its congestion space was determined.

Paper ID: P222
Author(s): Lukas Fryd and Ondrej Sokol
Title: **Effectivity of the agriculture business in EU: How subsidies affect effectivity?**

Abstract: The goal of this paper is to describe effectivity of firms conducting business in agriculture in the EU. Often used data envelopment approach on inputs and outputs based on productivity function seems to be oversimplified and sometimes deceiving because of market distortion caused by subsidies. In our approach, we include various effectivity ratios such as liquidity ratios, profitability ratios, debt ratios, operating performance ratios, cash flow indicator ratios, etc. in order to evaluate the total effectivity of the firm. We cluster the firms based on effectivity results and total country subsidies and discuss the effect of subsidies.

Paper ID: P223
Author(s): Tatiana Bouzdine-Chameeva, Samah Jradi, Bernard Delhomme and Anicia Jaegler
Title: **A unified efficiency DEA – based assessment of operational and environmental performance in wine sector**

Abstract: This study extends the application of a unified DEA-based efficiency for environmental assessment in wine sector. The sustainability efforts of the sector focus for many years on energy efficiency, water management, integrated pesticide management, which contribute to carbon emissions, pollutants usage, and waste production. To explore the estimation of environmental costs of pollutants we measure technical efficiency (as the relation of the desirable outputs to the inputs) and ecological efficiency (as the relation of the desirable outputs to the undesirable outputs). We combine then these measures into a unified performance measure. Treating further on pollutants as the inputs allow to increase desirable outputs and decrease pollutants and inputs. We incorporate then desirable and undesirable outputs into a unified measure (operational and environmental). We apply the environmental assessment to measure a unified efficiency of 50 wine producing companies in Bordeaux region in France. With the results of this study we expect to provide winemakers and regional authorities with the relevant information regarding eco-efficiency of sustainable practices existing in the French wine sector.

Paper ID: P224
Author(s): Luiza Badin, Cinzia Daraio and Leopold Simar
Title: **Bandwidth selection issues in nonparametric conditional frontier models**

Abstract: Nonparametric conditional frontier models include exogenous variables or environmental factors that may influence the production process, having a compound impact, affecting on one hand, the range of values for input x output vectors including the shape of the boundaries and, on the other hand, the distribution of the efficiencies. Since conditional efficiency estimators are defined by means of a nonparametric estimator of a conditional distribution function, smoothing procedures are involved and a smoothing parameter (the bandwidth) is required. Badin et al. (2010) proposed a practical data-driven technique for selecting the bandwidth. In this paper we discuss and compare several existing bandwidth

selection methods, in the framework of nonparametric estimation of conditional efficiency scores. We propose then a new data-driven approach based on least squares cross validation (LSCV) and the bootstrap, that is valid both locally and globally, and we show through Monte Carlo simulations that it outperforms the approaches available so far. An illustration on real data and comments on the practical implementation are also provided.

Paper ID: P226
Author(s): Roxani Karagiannis
Title: **Productivity growth in the Greek pharmaceutical industry**

Abstract: Our objective is to study the productivity change and its determinant factors in the Greek pharmaceutical industry during the period 2006-2015, in the backdrop of financial crisis and the implementation of regulation reforms associated to Memorandum of Understanding and the cost containment of pharmaceutical spending. We apply a two-stage non-parametric DEA methodology based on Malmquist index and regression analysis to estimate productivity change and its decomposition into technical change and relative efficiency change and the impact of various firm-level factors on productivity change and its components. We use as output variable the total sales of each firm and as input variables the raw materials, labour, capital, and marketing and advertising expenses. In the two-stage we use as explanatory variables the level of R&D investments, the export sales and the ownership status of each firm.

Paper ID: P227
Author(s): Lucie Chytilová and Jana Hanclova
Title: **Comparison of efficiency results for financial institutions using classical DEA model and StoNED model with contextual variables**

Abstract: The aim of the article is to analyse efficiency of European financial institutions in time period from 2010 to 2014. The basic intermediation approach is used for the identification of input and output variables. Final results of conventional methods of data envelopment analysis (DEA) and stochastic nonparametric envelopment of data (StoNED) method with the inclusion of contextual variables are compared. Advantages and disadvantages of each approach are discussed and analysed for the area of research.

Paper ID: P229
Author(s): Dráb Radovan and Kristína Kočišová
Title: **Change in technical efficiency in case of Slovak banks**

Abstract: The objective of the paper is to measure the technical efficiency of Slovak domestic commercial banks using the non-parametric data envelopment analysis (DEA). An input oriented window DEA model with constant and variable return to scale was applied, to investigate the efficiency of commercial banks´ deposits to loan transformation process. The analysis was focused on the 2005-2015 time period, as during this period has the banking sector gone through massive structural changes, changes in regulation, and was affected by the financial crisis. To capture the differences in the development three sub-periods (2005-2008; 2009-2012; 2013-2015) were considered. The development of the banking market as well as the development of economy has led to changes in efficiency. Therefore, the last part of the paper was focused on the efficiency changes determinants between individual sub-periods using the Malmquist index.

Paper ID: P231
Author(s): Lukas Fryd and Nataliya Soldatyuk
Title: **Measuring dependency between efficiency of financial sector and the economic growth**

Abstract: The mission of financial sector is to connect subjects with investment opportunities and subjects with capital. It implies that the efficient financial sector should contribute to the economic growth. A number of studies showed a positive relationship between financial development and the economic growth; however, there are several weaknesses associated with an approach used in these studies. The first weakness is the way how the efficiency of financial sector has been measured. It has been approximated using a few variables, which were subsequently used as predictors in the regression model. The second weakness is the econometric approach. The panel data methodology, specifically the fix effect assumes an independence between the analysed units. In the case of macroeconomic panel data that assumption is violated and parameter estimates may not be consistent under certain conditions. This study proposes a more comprehensive method of the efficiency measurement of

the financial sector using DEA. The panel data model robust to cross-sectional dependence then used to obtain consistent estimates. The analysis will be applied to several OECD countries in the time period 1995 to 2014.

Paper ID: P233
Author(s): Süleyman Kale and Mehmet Hasan Eken
Title: **Bank efficiency and growth in OECD ountries**

Abstract: The purpose of this study is to analyse whether the economic growth is affected from the bank efficiency in OECD countries. The research requires two stages. In first stage, considering different dimensions, the efficiency of banks over time will be measured by a data envelopment analysis model. In the second stage, effect of efficiency on economic growth will be investigated.

Paper ID: P234
Author(s): Petr Fiala
Title: **Applications of DEA in revenue management**

Abstract: The paper presents applications of DEA based approach in revenue management (RM). RM is designed to sell the right product, to the right customer at the right time, for the right price through the right channel, by maximizing revenue. Performance of RM systems can be evaluated by DEA approach. Revenue management is the process of understanding, anticipating and influencing customer behaviour in order to maximize revenue. The common modelling approaches assume that customers are passive and they do not engage in any decision-making processes. This simplification is often unrealistic for many practical problems. In the paper strategic customer behaviour is analysed. Today's customers actively evaluate alternatives and make choices. The paper introduces DEA based model and methods for a generalized problem. Combination of the methods for searching the efficient frontier and methods for specific requirements (weight restrictions, aspiration level changes) gives a powerful instrument to capture revenue management problems.

Paper ID: P235
Author(s): Grigory Pishchulov, Heinz Tüselmann and Rudolf R. Sinkovics
Title: **A bargaining solution approach to aggregation of ordinal preferences by means of DEA**

Abstract: Starting with the work of Cook and Kress, a significant number of studies have employed data envelopment analysis (DEA) as an approach towards aggregation of voters' preferences over a set of candidates in a ranked voting system. Such an approach leads to a DEA model with assurance region, in which the weights attached to the places in the ranking require discrimination. This is achieved by imposing a minimum threshold on the difference between the consecutive rank weights, which thus determines the intensity of rank discrimination. The choice of discrimination intensity is nevertheless problematic as it may favor or disfavor certain candidates and ultimately affects the candidate ranking. Several approaches to resolving this issue have been suggested in the literature but none can be considered universally acceptable. To this end, we propose a data-driven approach to choosing a discrimination threshold that intends, in the spirit of DEA, to remove subjectivity of choice and determine the threshold via Nash bargaining between the candidates. We demonstrate an application of this approach in the context of academic journal ranking.

Paper ID: P236
Author(s): Marcus Vinicius Pereira de Souza and Helaine Aparecida Da Silva
Title: **On assessing the quality in education of public school using IDEB and DEA**

Abstract: Historically, since the decade of 90, the Brazilian educational policies have been devoted to promoting improvements regarding to quality in education. Thus, taking into account the basic education, in the year 2007 was created the basic education development index (IDEB) for measuring and monitoring such quality at a national level. In conformity with what is mentioned up to here, this paper proposes using the output-oriented VRS envelopment model to assess the performance of 56 public schools in Juiz de Fora (in the Brazilian state of Minas Gerais). Besides this, the Wilson´s method (1995) for finding influential observations is shown here. Finally, results concerning to the measurement of efficiency and IDEB are presented and compared.

Paper ID: P240
Author(s): Babek Erdebilli
Title: **Improving an integrated DEA and intuitionistic fuzzy ELECTRE: A pilot study**

Abstract: This case study a combining of intuitionistic fuzzy elimination et Choix Traduisant La Realite (IFELECTRE) and data envelopment analysis (DEA) to choose the units with most efficiency. Firstly, the decision making units (DMUs) assessment problem is formulated by DEA and separately formulates each pair of units. Secondly, we utilize the opinion of decision makers (DMs) to be applied into an IFELECTRE. In This case, IFELECTRE identified as the intuitionistic fuzzy index of hesitation degree. DEA and IFELECTRE ranking do not modify the original DEA ranking model; rather, it advances the analysis by providing full ranking in the DEA context for all units by collect individual and hesitation opinions of DMs for rating the importance of criteria and DMUs.

Paper ID: P243
Author(s): Mengtian Xiao, Nan Zhu and Jingwen Lai
Title: **Board gender diversity and firm performance: A study of Chinese commercial banks**

Abstract: Although the males dominate the role of leaders in political and economic sector, the females have become an increasingly important force in a wide range of fields around the world. This paper examines whether a relationship exists between female executive directors and firm performance, which is expressed by the data envelopment analysis (DEA) efficiency, of Chinese commercial banks. The panel data is analysed by using the non-parametric test.

Paper ID: P246
Author(s): Labanya Pal and Chiranjib Neogi
Title: **Sources of productivity growth in Indian manufacturing industries: A DEA approach**

Abstract: This paper seeks to explain the productivity growth of Indian manufacturing industries over the period 1980-81 to 2009-2010. Data envelopment analysis technique is used to calculate and decompose the TFP growth into technical change, change in technical

efficiency and change in scale efficiency to identify the sources of productivity growth in Indian manufacturing. It was observed that gains from technical efficiency declined while technical change showed a rising trend over time. This clearly calls for an evaluation of management practices, training incentives, government policies related to foreign direct investment as well as the educational and industrial policies. This is not to say that such policies are necessarily misplaced but more effort is needed in such endeavors to ensure that the policies work hand in hand to maximize TFP growth and minimize any trade-offs in the efficiency components of TFP growth as evidenced above.

Paper ID: P247
Author(s): Nan Zhu, Qiang Huang, Luman Chen and Renbian Mo
Title: **On competitive power of Chinese commercial banks: DEA approach**

Abstract: This paper applies data envelopment analysis (DEA) method to measure the competitive power of Chinese commercial banks, based on 2007~2015 panel data. The competitive power that is expressed by the DEA efficiency and Malmquist index is discussed in order to promote the healthy and sustainable development of the banks and banking industry.

Paper ID: P248
Author(s): Mark Anderson, Rajiv Banker and Soonchul Hyun
Title: **Innovation, incentives and productivity in manufacturing**

Abstract: Growth in productivity in Canada's manufacturing sector has lagged other developed countries. Initiatives to improve productivity involve incentive plans and innovation. We use two-stage data envelopment analysis (DEA) to investigate how different types of employee incentive plans influence productivity at manufacturing plants in Canada. We also investigate how new and improved product and new and improved process innovation activities affect productivity. We use plant level data collected by Statistics Canada on sales revenue, labour inputs, and non-labour operating expenses to estimate output oriented efficiency for manufacturing plants in Canada. We relate DEA efficiency scores to the use of individual, group, and company level incentives, and lagged measures of innovation activities. We document that incentives moderate the impact of various innovation activities on productivity and that various types of incentives have differential impacts on productivity.

Paper ID: P250
Author(s): Ole Bent Olesen, Niels Christian Petersen and Victor V. Podinovski
Title: **DEA Models with ratio measures & potential ratio inefficiency**

Abstract: Focus in this paper is on the practical evaluation of strong and weak efficiency of decision making units (DMUs) in cases, where important data is available in the form of ratio measures only. The underlying axiomatic approach for data envelopment analysis (DEA) does not include the axiom of a convex production possibility set, since ratio measures in general are in conflict with the assumption of convexity. The computational solution of ratio models in DEA goes for this reason among others beyond the application of standard linear programming techniques, and binary variables embedded in Big-M constructs are needed. Anew type of so-called potential ratio (PR) inefficiency is shown to be an integral part of DEA with ratio measures. PR-inefficiency characterizes DMUs that are strongly efficient in the model of technology with ratio measures but become inefficient if the volume data used to calculate ratio measures become available. Potential ratio inefficiency can be tested by the programming approaches to be presented.

Paper ID: P251
Author(s): Said Gattoufi, Nadia Abaoub Ouertani and Yosra Boughdiri
Title: **A dynamic analysis of the efficiency of regional development programs in Tunisia using Malmquist index**

Abstract: The recent political changes in Tunisia have dramatically affected the regional development programs, favouring interior regions of the country. However, the results of the new orientations are debatable and there is a need for a scientific assessment of the efficiency of the newly implemented programs and an objective scientific analysis of their results. This study uses the Malmquist index to analyse the efficiency of these programs and set benchmarks in terms of regional development success. Moreover, Inverse DEA will be used to identify the conditions needed to reach the predefined targets in terms of development for the regions.

Paper ID: P252
Author(s): Arash Haseli, Mohamady Somayeh, Baghfalaky Masoud and Asghar Darigh
Title: **A comparative study of gradual improvement models in data envelopment analysis**

Abstract: The efficient target identified by DEA model can be very far away. To reach the target it requires large reduction in inputs and large increase in outputs. In such cases gradual improvement strategy is a useful tool. In this Paper we study these models, the first one is a model using for inefficient units, and secondly for those units that are technical efficient but not scale efficient. The third model is a gradual improvement model used for both inefficient units and efficient units that are not scale efficient improved them towards the scale efficient target directly. Finlay we have suggested an Algorithm for projecting the inefficient units towards the scale efficient frontier gradually. At each iteration, a closed neighbourhood is made for the actual situation and determine the nearest point of this neighbourhood by using the infinity norm from the set of the scale efficient targets and this point is selected for the next target. These successive target draw a path in the interior of the PPS from the initial point to the final scale efficient frontier.

Paper ID: P253
Author(s): Zhuang Miao and Tomas Baležentis
Title: **Performance decomposition and pathway optimization of China's air pollution control: Evidence from "Three regions and ten urban agglomerations"**

Abstract: Based on slack-based measure (SBM) method and an extended Luenberger productivity index decomposition, this paper takes "Three Regions and Ten Urban Agglomerations" in China as research sample to investigate and decompose the environmental performance of air pollutants, including SO2, NOX, and CO2 emissions. We discuss the resolution of air pollution control and prevention in China. The results show that the crucial contributors to China's atmospheric environmental inefficiency are SO2, NOX, CO2 emissions and fossil energy consumption, and the atmospheric environment inefficiency regions present a decreasing trend geographically from Northern China to Southern China. The high performance of SO2 emissions make great contribution to the growth of atmospheric environmental total factor productivity (AETFP) in China's 11th "Five-Year Plan" period, while the performance of NOX emissions shows a dissatisfactory level. The enhanced environmental regulation can

contribute to the growth of AETFP. Despite the differences in the technical progress in various regions, the technical progress is enough to offset the negative impact of declining technical efficiency on AETFP.

Paper ID: P257
Author(s): Somayeh Shafaghizadeh, Sadoullah Ebrahimnejad and Mehrzad Navabakhsh
Title: **Designing a network data envelopment analysis (NDEA) model to evaluate resilience of supply chain with stochastic data**

Abstract: In this study, the data envelopment analysis model for designing a resilience supply chain network under conditions of uncertainty is taking into consideration, resilience performance indicator with stochastic data in the network automotive industry. The purpose of this study is to measure performance a decision-making by combining two approaches: Resilience and chance constrained network DEA and analysing of resilience supply chain network with using data envelopment in conditions of uncertainty. A number of major indicators, resilience in the automotive industry include: flexibility, responsiveness, accessibility, agility, diversity, adaptability which will be measured by using several operational level. Thus, the first step is to identify the key supply chain processes in the industrial environment and establish relationships between organizational units and identify all the inputs and outputs of organization are obtained randomly. After the formation of the main DMUs in order to measure the efficiency of processes, explain of the network DEA model in conceptual framework, the objectives, constraints, variables and then apply linearization techniques have implemented.

Paper ID: P258
Author(s): Audrone Jakaitiene and Dovile Stumbriene
Title: **Data envelopment analysis in construction a composite indicator for education monitoring**

Abstract: This research focuses on the construction of a composite indicator for the education monitoring. Socio-economic phenomena are complex and hardly can be measured by a single descriptive indicator – it should be represented with multiple dimensions.

Phenomen such as education might be measured and evaluated by composite indicators. We constructed the index following structural CIPO framework, which decomposes education performance to context, input, process and output (CIPO). Composite indicator for education monitoring was calculated for 26 EU countries. For methodologically consistent data for a country we used 2002-2014 annual data from EUROSTAT and OECD databases. For each country we selected 45 variables. We calculated weights employing principal components and DEA approaches. For the aggregation of variables, we applied linear function. Additional restrictions to DEA weights were applied compared classical "benefit of the doubt" approach. We calculated separate sub-indices for input, process and output and performed bottom-up approach. Goodness of fit of the index was assessed checking for Granger causality using context variables.

Paper ID: P259
Author(s): Arezoo Gazori Neishabori, Kaveh Khalili Damghani and Ashkan Hafez Alkotob
Title: **Development of network dynamic data envelopment analysis for industrial management institute performance evaluation system using games theory**

Abstract: The main objective of this study is to measure performance impressionable and effective processes in industrial management institute uses data envelopment analysis for dynamic grid and approach to game theory. According to this study, the performance evaluation with the approach of the data envelopment analysis using operations research techniques to obtain the solution of the model will be addressed in the Organization of Industrial Management, Therefore, the first step is to identify the main industrial management institute and determine the relationships between the levels and units of each process and identify all the inputs and outputs of system which have been achieved through communication between processes. After the formation of the original DMUs in order to measure the efficiency of operational processes, the definition of a Network of DEA model within the framework of the conceptual model, objectives, constraints, variables and parameters and then applying linear construction techniques. Next step, development of network dynamic data envelopment analysis will be achieved using games theory, and finally solve the provided model by the software LINGO.

Paper ID: P261
Author(s): Juha Eskelinen and Abolfazl Keshvari
Title: **Efficiency evaluation of public employment services in Finland: A non-parametric matching function approach**

Abstract: We study the performance of the public employment services (PES) in Finland. In this project, the matching of vacancies and job seekers are evaluated. In a close collaboration with the Ministry of Economic Affairs and Employment, the performance of the PES offices are assessed and the required efficiency measures and performance indicators are defined. We utilize one-stage DEA (DEA-1) in an intertemporal analysis to determine the shape of a matching function and analyse the effects of operational conditions. A business intelligence application is then developed and the matching efficiency indicator is regularly reported as part of a decision support system to the authorities in the ministry and offices.

Paper ID: P262
Author(s): Mark Anderson and Dongning Yu
Title: **Operating and investing efficiency of real estate investment trusts (REITs)**

Abstract: We develop DEA models to investigate how economic conditions affect the operating and investing efficiency of real estate investment trusts (REITs) in North America. We estimate efficiency separately for REITs that invest in industrial and office, retail, residential, health care, and hospitality properties. For operating efficiency, outputs include measures of leased properties, and inputs include various operating expenses. For investing efficiency, outputs include measures of returns on capital, and inputs include various debt and equity capital and administrative expenses. We examine how efficiency is affected by changes in local economic factors such as unemployment rate, housing price, GDP, and personal consumption expenditures at the geographic location level. We find that the shifting economic conditions significantly and systematically influence operating and investing efficiency of REITs, and that these effects differ depending on the type of investment property and other contextual conditions.

Paper ID: P268
Author(s): Josef Jablonský
Title: **Ranking of countries in sporting events: A two-stage data envelopment analysis model (a case of Olympic Games 2016)**

Abstract: After sporting events the participating countries are ranked according to the number of gold, silver and bronze medals. A lexicographic ranking is usually applied which leads to higher ranking of countries with one gold and no other medals comparing to countries without any gold but with several silver or bronze medals. Moreover this ranking does not take into account the specific conditions of the countries (population, economic strength, etc.). The aim of the paper is not only to evaluate the absolute achievements of the countries but evaluate their performance with respect to the resources they can use.
A two-stage DEA model is formulated and solved by an original procedure. The first stage evaluates the performance of the countries in training of athletes and the second stage evaluates the achievements of the nominated athletes. The models with constant returns to scale and weight restrictions are applied. The models and their results are illustrated on the case of Olympic Games 2016 and compared with the conventional results.

Paper ID: P271
Author(s): Reza Maddahi
Title: **Resource allocation by applying inverse data envelopment analysis method**

Abstract: In this study, inverse data envelopment analysis (DEA) technique is applied for allocating fixed resource between homogeneous decision-making units (DMUs). Two purposes are followed in the proposed resource allocation method; the first one is: after resource allocation, the efficiency scores of DMUs remained unchanged and the second one is: increasing in the outputs according to the allocated resource. The recommended method considers two cases; 1) the assigned resource is dependent on other inputs. Therefore, the kind of considered resource, in this case, is similar to other inputs and, 2) the allocated resource is independent of other inputs.

Paper ID: P274
Author(s): Pegah Hajimirzakhoshnevis and Peter Teirlinck
Title: **Geographical proximity and economic performance of space industry actors in Belgium**

Abstract: In this study, we focus on space clusters in Belgium including; SKYWIN and FLAG and we employ data from the Belfirst database. The aim of our study is to investigate the effect of geographical proximity on performance efficiencies of space companies in Belgian clusters. In this regard, we propose a two-stage approach involving of performance evaluation of the firms using data envelopment analysis (DEA) and investigation of proximity geography effects on efficiency. Firstly, we estimate the relative efficiencies of the firms using data envelopment analysis. In the second stage, we investigate the geographical proximity effect on technical efficiency and we would like to test whether the closer distance, the more knowledge transmission and the more opportunity for the firms to perform efficiently.

Paper ID: P275
Author(s): Israfil Roshdi, Paul Rouse, Dimitris Margaritis, Maryam Hasannasab and Rolf Färe
Title: **A generalised directional distance function**

Abstract: The directional distance function (DDF) of Chambers, Chung, & Färe (1996, 1998) has been proven to be a useful and popular tool in performance measurement, efficiency and productivity analysis. DDF measures inefficiency by simultaneous expansion of outputs and contraction of inputs along with a pre-assigned direction vector. In this paper, we generalise the idea of direction and develop an extended version of DDF - called generalized directional distance function (GDDF) - that measures inefficiency within a "direction cone" rather than relying on a single direction vector. The direction cone is spanned by a finite number of exogenously given direction vectors within which the GDDF generates an optimal endogenous direction vector by optimizing (either maximizing or minimizing) against the efficient frontier. The GDDF satisfies similar fundamental properties as its special case DDF does viz. representation, monotonicity and translation. We further demonstrate an implicit duality relationship between the GDDF and the profit function. Finally, we propose a linear programming based computational procedure using data envelopment analysis for computing the value of GDDF.

Paper ID: P276
Author(s): Israfil Roshdi, Maryam Hasannasab, Rolf Fare, Paul Rouse and Dimitri Margaritis
Title: **Hyperbolic distance function and profit ratio: Efficiency decomposition and computations**

Abstract: Färe et al. (2002) demonstrate that, under CRS, HDF may be estimated as the square root of the Farrell output efficiency score. Following from Färe et al., we establish an overall efficiency decomposition into HDF technical efficiency and allocative profit ratio efficiency under VRS. We propose two computational procedures for measuring HDF efficiency and the profit ratio using DEA. First, we transform the nonlinear HDF under VRS into an equivalent conic program with linear constraints plus a single extra cone constraint. This transformation not only provides a direct method for computing the exact value of VRS-based HDF but also offers a dual counterpart for HDF as conic optimization. Second, combining facet structures of a VRS-DEA technology set with the linearity property of linear fractional isoquants, we propose an LP-free computational procedure to calculate the value of the profit function. This procedure can be easily adapted to the case of value-based technologies (Tone, 2002) which are well-suited for competitive markets with heterogeneous inputs and outputs along their varying prices. We illustrate our approach and computational procedures using a real-world data set.

Paper ID: P277
Author(s): Wan Qiang, Zhu Nan and Huang Qiang
Title: **Frontier analysis of Chinese securities companies: DEA approach**

Abstract: The efficiency and its change of any organizations, profit making or non-profit making, is most important factor for survival and growth of the organization. The data envelopment analysis (DEA) technique is one of the most popular and effective tool to measure the relative efficiency and its change hence is appropriate to make comparison among similar organizations with multiple outputs and inputs. This study performs frontier analysis and measures the relative efficiency and Malmquist index of Chinese securities companies using DEA approach.

Paper ID: P278
Author(s): Ayhan Gölcükcü and Hasan Bal
Title: **Adding a different meaning to FDEA by triangular norms**

Abstract: The fuzzy data envelopment analysis (FDEA) pioneered by Sengupta and branched out as can be seen in the survey of Hatami-Marbini et al. and later Emrouznejad at al. This field has not yet reached the desired level in its entirety. Current studies of FDEA are still under the framework of fuzzy mathematical programming and away from the representing the full power of DEA. The triangle membership functions and the triangular norms (t-norm) in fuzzy logic constitute an important place, while the simplex concept based on a triangular surfaced polyhedron is the basic stones of linear programming and DEA. Therefore, our scope of the study is the mathematical demonstration of the relationship between t-norms and DEA. This will add a different meaning to the FDEA.

Paper ID: P279
Author(s): Hasan Bal and Ayhan Gölcükcü
Title: **Comparison of alpha-levels in fuzzy data envelopment analysis**

Abstract: Data envelopment analysis (DEA) is a noticeable technique which proves itself in performance measurement. It is combined with many techniques and applied in a wide range of areas. In real world, in general, the real data processed in DEA analysis are not crisp and have some problem which can be considered as fuzzy. Most commonly used efficiency evaluation method in fuzzy DEA (FDEA) application is alpha-cut approach which transforms fuzzy data to crisp levels. Our objective is to propose any easy way of comparing efficiency scores by applying group comparison methods when there exist missing values which can be accepted as fuzzy.

Paper ID: P280
Author(s): Maryam Hasannasab, Dimitris Margaritis and Psillaki Maria
Title: **Acquisition premiums and performance of EU-15 banks**

Abstract: We examine the impact of M&As in the EU-15 on bank performance during 2002–2015 using a network DEA model. The main questions we investigate are the following: Do premiums paid for acquisitions reflect (profit) efficiency and productivity gains? Are premiums paid lower in countries with stricter regulatory regimes? Are they higher for acquiring targets in more concentrated markets? Do M&As add value? Is bank productivity related to size? We calculate changes in cost and profit efficiency one year prior and up to three years after the merger. We compare the performance of banks engaging in mergers with a control group of non-merging large banks. Throughout this analysis, we pay particular attention to the role of risk and capital on bank efficiency. Further, we use a new measure of scale elasticity to shed more light on the 'bad management' hypothesis.

Paper ID: P281
Author(s): Behrouz Arabi, Rui Sousa, Maria Portela and Ana Camanho
Title: **Manufacturing strategies and operations performance: A frontier approach**

Abstract: Aligned with the operations management literature, this paper explores the effects of best practices implementation and investment on the firms' performance. A firm performance can be evaluated relative to performance frontiers. There are two types of performance frontiers in the literature. The first is evaluated by the firms' actual performance which is named operating frontier and the latter, asset frontier, is defined as the best performance can be achieved using the current assets of a firm. In this paper, by applying the DEA methodology, we measure the performance of the firms with a similar value of assets to indicate the impacts of best practices implementation on the firms' performance. In addition, we examine the trade-offs amongst the performance variables for the firms operating far and close to the asset frontier in order to determine the best manufacturing strategy of a firm.

Paper ID: P282
Author(s): Emre Dünder, Serpil Gümüstekin and Mehmet Ali Cengiz
Title: **A second stage approach in efficiency analysis via multivariate adaptive regression splines**

Abstract: It is an attractive task to investigate which external variables (except input-output variables) have significant effect on the efficiency values. This task is performed with second stage analysis. In literature several approaches were proposed such as regression modelling, Bayesian networks, decision trees etc. for the second stage analysis. As our best knowledge, multivariate adaptive regression splines (MARS) is not used within second stage analysis. In this study we integrated MARS into second stage analysis as an alternative approach. Due to the nature of MARS, it is possible to eliminate redundant variables. This property of the MARS motivates us to implement MARS in second stage analysis. Experimental results are obtained in health system efficiency analysis. Efficiency scores are obtained via data envelopment analysis (DEA). All the implementations are performed in R software. According to results we conclude that MARS is a convenient approach in second stage analysis for efficiency analysis.

Paper ID: P286
Author(s): Somayeh Tabatabaee, Mohammad Reza Mozaffari and Josef Jablonsky
Title: **Revenue efficiency in DEA-R based on value efficiency**

Abstract: In term of revenue efficiency, the standard output of a decision making unit (DMU) is determined by considering the inputs and specifying the ratio of outputs. In this paper, we aim to suggest a DEA model for revenue efficiency measurement based on the manager's preferences, along with introduction of units at the most preferred solution (MPS). Therefore, the revenue efficiency of the DMUs are calculated for each bank branch based on value efficiency in DEA and standard output are recommended for those branches.

Paper ID: P288
Author(s): Razieh Mehrjoo
Title: **Investigating some results in DEA production games, using FDH models**

Abstract: DEA production game, have been investigated by Borrero (2016). They assumed the technology of recorded observations which exhibit constant return to scale or variable return to scale. In this paper, we consider agents which their production technology does not follow the convexity principle. And the reference set of each DMU has just one member. In this case of DEA production games, using FDH models, we prove some results.

Paper ID: P291
Author(s): Grzegorz Ginda and Mirosław Dytczak
Title: **What makes DEA successful in civil engineering applications?**

Abstract: A bibliographic database query about civil engineering DEA applications usually lists more than a hundred scientific works from three recent decades. The works deal with diverse problems. Contents of the works is analysed to find out what helps in making DEA applications in civil engineering so successful. Gaps and weaknesses which hinder further development in civil engineering DEA applications are also discussed. Some hints about possible remedies for eliminating the gaps and weaknesses as well as other possible DEA enhancements which would make the technique even more usable for civil engineering are proposed in the paper too.

Paper ID: P292
Author(s): Natalia Iwaszczuk and Grzegorz Ginda
Title: **A DEA-based framework for financial investment portfolio identification**

Abstract: Nature of financial market investment instruments makes them especially susceptible to risks. Actual applications of DEA suggest that it is a valuable tool for supporting decisions in diverse problems under risks. It seems that DEA flexibility and capability of facilitating reliable assessment of efficiency constitute basic DEA features. The features make DEA particularly suitable for testing actual efficiency of financial market investment instruments. A framework for

the reliable composition of effective portfolio of financial instruments is proposed in the paper. The framework is based on the application of DEA for the assessment of portfolio composition alternatives. Case study is also provided in the paper to illustrate merits of the proposed framework.

Paper ID: P294
Author(s): Selin Ceren Turan and Mehmet Ali Cengiz
Title: **Second stage stochastic frontier analysis using heuristic algorithm methods for estimation of health system efficiency for OECD countries**

Abstract: In recent years, health policy makers have focused on the performance of their health systems and many countries have introduced reforms to improve the performance of their health systems. In recent literature, there are two common approaches to estimate the efficiency. Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are two alternative method used frequently to estimate the boundary functions and to measure the production effectiveness. Whereas DEA is a non-parametric method that uses linear programming, SFA is a parametric method that uses econometric methods. SFA approach establishes a functional relationship between described variables such as cost, profit and production and explanatory variables such as input, output, and environmental factors. In this study, our main aim is to estimate health system efficiency across OECD countries using SFA approach. Then, it is considered to investigate other factors affecting the health sector efficiency by using heuristic algorithm methods such as bee colony algorithm and differential development algorithm.

Paper ID: P296
Author(s): Rajiv Banker, Hyunjin Oh, Gordon Potter and Kyung-A Sun
Title: **Impact of franchising on the operating efficiency of hotels**

Abstract: We investigate how organizational structure of hotel properties affects operating efficiency. Principal-agent models and transaction cost economics theory suggest franchised properties are managed differently than company-owned properties. However, few studies have explored the impact of franchising on performance. We use a panel data set between 2010 and 2014 from over 4000 properties in the Unites States and compare the efficiency of

franchised and company-owned hotels. We develop a DEA model of hotels' operations that recognize their unique cost structure and the implications of their different strategic positioning. We examine the impact of franchising and strategic positioning on managing different types of costs. We document that the franchised hotels' efficiency is lower than that of company-owned hotels, suggesting that the loss in efficiency due to the franchisee's incentive to free ride on the brand name is greater than the benefit from reduced agency costs.

Paper ID: P297
Author(s): Seyed Hassan Aghili and Mohsen Rostami Malkhalife
Title: **Predict the performance of bank branches by multilayer perceptron network**

Abstract: Identify the strengths and weaknesses of each unit, makes it possible to the managers to make more accurate decisions to reform and strengthen the weaker units adopt. It is possible to recognize the performance of units under evaluation. Since the performance will show how the solutions will be simple to determine the effectiveness of particular importance. In units that are time-dependent change, finding patterns is useful from time to calculate performance. In modern management, the scientific method has been developed to improve the quality system. Data envelopment analysis (DEA) is one of the most applicable methods to evaluate and compare multiple units or one unit is at different times. It has been proven that artificial neural network in data mining tools, the best is to do the classification. Multi-layer perceptron (MLP) neural network usually used due to the convergence fast and easy implementation. In this paper, we calculate the number of units unknown dealt with neural network. This method with the least time without solving multiple linear programming conducted in and in the end the results are compared with the DEA.

Paper ID: P298
Author(s): Alireza Amirteimoori and Ali Ahadzadeh Ghannad
Title: **Network data envelopment analysis for supply chain performance evaluation: Case of poultry industry**

Abstract: Classical DEA models make no assumptions concerning the internal operations of a DMU. Rather, the DEA model treats each DMU as a "black box" by considering only the initial inputs consumed and final outputs produced by it. The current study develops a

network-DEA model for characterizing and measuring supply chain efficiency when intermediate measures are incorporated into the performance evaluation. We have taken the case of Poultry industry supply chain in Gilan province. And a real case on 10 poultry chains in 2013 has been illustrated to verify the applicability of the proposed approach. The results showed that the efficiency of units were bad operating practices that only one unit was efficient. This means that the members of farms could decrease their costs to be more efficient in the chain. Therefore, the results of the study gave information to policy makers and extension services on how to better aim efforts to improve poultry chain efficiency.

Paper ID: P299
Author(s): Wen Song and Gong-Bing Bi
Title: **A performance evaluation of China's coal-fired power generation from models comparison perspective**

Abstract: Data envelopment analysis (DEA) has been widely applied to evaluate performance in the power generation industry. Most of these studies, however, treat the production system as a "black box"; few studies attempt to deal with the case of China's thermal power generation industry in the framework of network DEA. Also, few studies address whether the performance figures evaluated by different models are consistent or divergent. From the managerial standpoint, the decision maker should examine the features of different models and make a reasonable choice. In this paper, we divide the thermal power generation process into two different stages: the production stage and the pollutants abatement stage, with the pollutants as the intermediate products. Then we propose four different network DEA models according to different linkages between the two stages. These models are applied to an empirical case and the results are compared using some statistical techniques. We find that most of the model pairs show divergent features and the model proposed by the authors has the highest distinguished power in the empirical study.

Paper ID: P300
Author(s): Hédi Essid and Sofiène Omri
Title: **DEA game cross-efficiency approach to portfolio selection**

Abstract: In this paper we present an application of the DEA game cross-efficiency model in portfolio selection where DMUs are viewed as competing agent for available funds (investment). The model provides unique cross efficiency scores which will be determined through an iterative approach leading to the Nash equilibrium. The approach is applied to stock portfolio selection in the French stock market. We examine the coherence of the model as a tool for portfolio selection through comparison with other benchmark portfolios for a 5-year sample period from 2010 to 2015.

Paper ID: P305
Author(s): Mohsen Rostamy-Malkhalifeh, Asieh Gholaminezhad and Nasim Arabjazi
Title: **Determine stability region in DEA with maintenance of classification of extreme efficient DMUs**

Abstract: An important discussion in data envelopment analysis (DEA) is sensitivity analysis. In this paper, sensitivity analysis is considered when inputs and outputs under evaluated decision making units (DMUs) change and other DMUs remain constant. According to special importance of efficient DMU in DEA, the biggest stability region corresponding under evaluated extreme efficient DMU will be obtained whereas classification of all extreme efficient DMUs do not change. Finally, a numerical example is solved by the presented method and the conclusions are discussed.

Paper ID: P307
Author(s): Shadi Mohseni, Razieh Mehrjoo and Mohsen Rostamy-Malkhalifeh
Title: **Measuring supply chain cost efficiency with interval data by DEA models**

Abstract: Data envelopment analysis is one of the most accurate approaches to evaluate the performance of supply chain, so that provides how the performance of improvement, points, recognition of an inefficiency resources and trying in order to improve them. In the

actual world, more information is obtained in forms of incorrect that one of the most inaccurate information is interval form. In this paper, new approach was presented for investigating the supply chain when information is in form of the interval, and finally this model has been used for numerical examples.

Paper ID: P308
Author(s): Nasim Arabjazi, Asieh Gholaminezhad and Mehdi Toloo
Title: **A goal programming model in data envelopment analysis cross-efficiency evaluation**

Abstract: Cross-efficiency evaluation is an effective approach for ranking decision making units (DMUs) in data envelopment analysis. The existence of alternative optima for the DEA weights may reduce the usefulness of the cross-efficiency evaluation method. So, it is recommended that secondary goals be introduced in cross-efficiency evaluation. In this paper we propose a goal programming model for cross-efficiency evaluation. A numerical example is solved by our proposed method.

Paper ID: P309
Author(s): Erwin Lin
Title: **Evaluating performance of rail transport using network DEA model**

Abstract: Rail transport has long played an important role in the economic development for a country, thus enhancement of its performance is crucial to be sustainable in a competitive context. Many studies have endeavoured to rail transport performance evaluation in the past but one of common drawback is that they did not take the internal structure of rail system into account. In practice the rail system can be divided into several subsystems, without taking each subsystem into consideration, one cannot obtain more insight to railway's operation. To rectify, we propose a network data envelopment analysis (NDEA) model which can be used to evaluate the performance of rail transport system and its subsystems. We divide the rail transport into three subsystems, namely: infrastructure maintenance, transport service production, and service transformation, and then evaluate the performance of whole system, as well as each subsystem, including technical and scale efficiencies by

using NDEA. We use 19 European railways in the case study. Based on our NDEA model and empirical results, one can obtain more insight to railways' operation and thus propose more effective strategies for improvement.

Paper ID: P310
Author(s): Zenaida Garambas
Title: **Performance evaluation using data envelopment analysis: A Case of a Philippine university**

Abstract: Performance appraisals are a part of career development and consist of regular reviews of employee performance within organizations (Muchinsky, 2012). This study assessed the performance of the eight colleges of a University vis-à-vis their efficiency along instruction (faculty and students), research, extension services, and program requirements. Data envelopment analysis (DEA), a non-parametric technique, was utilized to measure the efficiency of the different colleges. The data (inputs and outputs) were treated with xDEA software in Microsoft Excel. It determined the efficiency of the different colleges; the peer groups and weights of the colleges; the virtual inputs/outputs or improvements of the colleges to be in the efficient frontier; and the reference set proposed for inefficient colleges for benchmarking /efficient colleges. The colleges with the best practices in the different performance indicators were identified. It was found out that there is no particular single college which is "fully efficient" in all the indicators.

Paper ID: P312
Author(s): Jin-Li Hu and Yi-Jiun Lin
Title: **Disaggregate output and input efficiencies of Taiwan's regions**

Abstract: This paper computes the disaggregate output and input efficiencies of nineteen Taiwan's administrative regions during 2004-2015. The non-oriented slack-based data envelopment analysis (SBM-DEA) with undesirable outputs model proposed by Tone and Tsutsui (2011) is used. There are six inputs (employment, local government expenditure, household and commercial electricity, industrial electricity, residential water, and productive water), two undesirable outputs (SO2 and sewage), and one desirable output (regional GDP). The

target/actual ratio (or its inverse) proposed by Hu and Wang (2006) and Hu and Chang (2016) is then applied to compute disaggregate input and undesirable output (or desirable output) efficiency scores of Taiwan's regions. Taiwan has been very inefficient in inputs and undesirable outputs. However, there is not much room to improve in the GDP efficiency for Taiwan. The north regions are relatively much more efficient than the ones in other areas with respect to all inputs and undesirable outputs. Empirical findings support the environmentalist viewpoint that Taiwan should emphasize improvement of life quality and sustainability, instead of economic growth.

Paper ID: P314
Author(s): Maja Mihaljević Kosor, Lena Malešević Perović and Silvia Golem
Title: **Efficiency of public spending on education: A data envelopment analysis for EU-28**

Abstract: One of the main objectives of education policy is to improve educational outcomes. If resources are used inefficiently they will fail to maximise those outcomes. In this paper we discuss and survey conceptual and methodological issues related to the measurement and analysis of efficiency in the context of education. Second, using data envelopment analysis we estimate technical efficiency of public spending on education for EU-28 and discuss and compare the results. Obtaining information about the efficiency of public spending on education is of relevance to many parties. This information can be used to formulate policy proposals, promote 'yardstick' competition in the areas where the lack of market mechanisms is most evident and to improve the monitoring of education. A further motivation of our research is to discover the key obstacles to efficiency gains in the education system and to develop an outline of a policy agenda for improvement focusing on EU-28.

Paper ID: P318
Author(s): Pekka Korhonen, Akram Dehnokhalaji and Nasim Nasrabadi
Title: **A lexicographic radial projection onto the efficient frontier in data envelopment analysis**

Abstract: Our aim is to develop a lexicographic approach to projecting radially any unit onto the efficient frontier – not only onto the weakly efficient frontier. The approach is based on the idea to apply radial projection by stepwise dropping component(s) from the radial

projection vector until the efficient frontier is reached. The approach has two main difference compared to the traditional approach: 1) the target unit on the efficient frontier is found in the spirit of radial projection and 2) the (in)efficiency score is not necessarily the same for all controllable variables. A numerical illustration and an empirical example are used to demonstrate the approach.

Paper ID: P320
Author(s): Junfei Chu
Title: **A new common-weight multi-criteria decision-making approach for technology selection**

Abstract: Aiming at the technology selection problem, we propose a new common-weight multi-criteria decision-making (MCDM) approach in the evaluation framework of data envelopment analysis (DEA). Firstly, in one input and multiple outputs technology selection case, we give an improved model which can be used to guarantee that only one decision making units (DMUs) (referring technologies) can be evaluated as efficient and selected as the best performer. Then, we extend the model to handle the multiple inputs and multiple outputs technology selection case. Two algorithms are given to linearly solve the extended model and to guarantee the uniqueness of the final optimal set of weights respectively. The proposed approach not only ensures that the final evaluation result is Pareto optimal but also reduces time consumption when applied to situations with large data set. Finally, the proposed approach is compared with traditional approaches on several numerical examples; further a numerical experiment is given to show that the proposed approach is more suitable for applying in the situations in which the data set is large, compared with the traditional technology selection approaches.

Paper ID: P323
Author(s): Ibrahim Hassan Osman, Abdellatef Majed Anouze, Habin Lee, Zahir Irani, Baydaa Al-Ayoubi, Tunç Medeni and Vishanth Weerakkody
Title: **A cognitive analytics management framework to evaluate performance of e-government services from users´ perspective**

Abstract: Electronic government services (e-services) involve the delivery of information and shared-value services to various stakeholders via the Internet of Things and other modes. A cognitive analytics management (CAM) framework is proposed to frame, model, and evaluate the performance of the joint online and dynamic interaction between users and electronic government services to increase take-up and close the digital divide. An innovative framework is proposed based on three overlapping processes: a cognitive process to frame the problem in analytics terms; analytics process which integrates data envelopment analysis and classification and regression trees to generate insights and improvement recommendations and a management process to provide the necessary support and implement recommendations. Empirical experience is reported on a sample of 3178 users from 13 Turkish e-services. The implementation of recommendations has generated significant impacts in terms of estimated financial savings; additional improved e-services and increased take-up. The paper concludes with some limitations and further research directions.

Paper ID: P326
Author(s): Chao-Chung Kang
Title: **Performance evaluation of metro-transit system: A network DEA with parallel network structure**

Abstract: This study proposes a network data envelopment analysis (NDEA) model with considerations of network and parallel structures to measure the performance of metro transit. The model is applied to simultaneously investigate the overall operational performance, efficiency, and effectiveness of metro-transit. In a word, the overall operational performance of metro transit can be decomposed into the efficiency and effectiveness. The empirical case is conducted to investigate performance of the Taipei metro transit system (TMTS) in which provides with two types of public transport services, high-capacity and medium-capacity,

for passengers in Taipei metropolitan area. The intermediate inputs and shared-inputs are also considered in this model except multiple input-output variables. The time series data of multiple input-output, shared-input, and intermediate inputs used in this model are obtained from annual report of TMTS between January 2011 and December 2014. The results conducted by this network DEA model with parallel structures can be used to measure the efficiency and effectiveness of high-capacity, medium-capacity systems as well as overall performance of Taipei metro-transit.

Paper ID: P327
Author(s): Jens Leth Hougaard, Kurt Nielsen and Athanasios Papakonstantinou
Title: **A simplified two-attribute yardstick procurement auction with endogenous scoring**

Abstract: This paper describes a two-attribute procurement auction that turns advance procurement auctions into posted prices using DEA based yardstick competition. The resulting yardstick bids is displayed to the principal that directly picks the most preferred yardstick bid as in a market with posted prices. The principal's choice reveals boundaries on his underlying preferences, which are used as endogenous scoring to extract more information rent. The process reduces the interaction to a minimum and makes the procurement process very flexible and suitable for automated data-driven procurement. The auction requires no a priori scoring function (articulation of preferences) and the suppliers simply submit bids in a single round. The procurement mechanism extend the basic DEA based yardstick auction and addresses the problem with extreme equilibria analysed in the paper „A sealed-bid two--attribute yardstick auction without prior scoring" by Hougaard, Nielsen and Papakonstantinou (2016).

Paper ID: P329
Author(s): Au Ton Nu Hai, Ludwig Lauwers and Stijn Speelman
Title: **Environmental efficiency of marine cage lobster aquaculture in Vietnam**

Abstract: Marine cage lobster aquaculture in Vietnam has been considered as a high return but also a high risk industry due to the frequency of disease outbreaks. That is because lobsters in Vietnam are fed almost exclusively on fish by-catch. As a result the sector has

been facing a number of environmental problems in the form of nutrients surpluses. One of the visible consequences is the decreases in production. Therefore, this study used two stage bootstrap DEA to investigate to which extent the nutrient losses can be reduced to produce the current level of output and to identify the determinants of environmentally efficiency based on the cross sectional data of 361 marine cage lobster farms in Vietnam grouped into spiny lobster, green lobster and mixed cultivation (both type of lobster). The result shows that there is substantial environmental inefficiency in all three groups due to overuse of inputs. Moreover, the cage cleaning frequency during the cultivating period, distance from inland, equipment cost, the volume of cultivating area, number of cage, existence of other discharge and movement variables were found to be important factors affecting their environmental efficiency scores.

Paper ID: P330
Author(s): Rolando Valdivia
Title: **Political regulations influence in a "multi-market-point-demand" of hydrocarbon products. Case of study: recapitalization period in Bolivia South America 2010 – 2016.**

Abstract: The purpose of the paper is to evaluate the technique efficiency Malmquist–DEA VRS in a-multi-market-multi-point-energy products, in a regulate market, based on different political government laws in the downstream chain. Three products as, Diesel, Oil, GLP, was chosen in the new recapitalization period. Different approach strategies are considering as a technological option to cover the demand "vs" volume delivery "vs" the real. The research analysed the market in the most three important cities of the country, that means 76% of the total demand with different storage levels of the products. Following this framework, month a month the Malmquist index is obtained in five years, and then the DEA_VRS is applied to. The study matched the efficiency results with the different policies, in order to determine which one of them is better to optimize the decision to affront the demand in the regulate market.

Paper ID: P331
Author(s): Veljko Bojovic
Title: **Subsidizing (foreign) direct investments - ex post efficiency analysis with DEA**

Abstract: A great number of countries in the world, including Serbia, use subsidies and other instruments (e.g. tax incentives) in order to encourage both foreign and domestic direct investment, with the aim of increasing employment and accelerating regional and technological development. Bearing in mind the increase of amount of money for this type of subsidy, there is a need to assess the efficiency of this policy. In this paper, as a framework for analysis, concepts of external and internal efficiency of subsidizing investments are defined. Due to lack of data for expenditures of other countries, only internal efficiency of policy, which has been conducted by the Government of the Republic of Serbia for the last ten years, is analysed using an appropriate DEA model with categorical variables. The results showed that there were potential savings in the budget, as well as differences in efficiency between the two different institutional program conducted by the Government (through public contest and with use of discretionary power) and between foreign and domestic investors. In addition, suggestions are given for further research which would give more broader and precise results.

Paper ID: P332
Author(s): Chunxia Jiang, Chunan Hu and Shujie Yao
Title: **Friend and Foe: The impact of shadow banking on bank performance, financial stability, and economic growth in China**

Abstract: After the 2007-09 global financial crises, shadowing banking has increased drastically in China. While shadow banking involves financing activities that are out of regulatory oversight and pose significant treats to financial stability, it is argued to have helped stabilise output growth. Shadow banking in China is very different from typical shadow banking activities in developed countries, such as US, as banks are involved in a large part of shadow banking activities. In this paper, we address two issues using bank/provincial level data over the period 2002-2015. First, we examine how shadow banking activities affect bank efficiency and bank risk-taking. We employ both a one-stage SFA model and a DEA model to estimate

bank cost and profit efficiency. We examine the impact of shadow banking on: (1) different efficiency measures obtained from DEA and SFA, as well as the average rank of efficiency scores using DEA and SFA; and (2) risk measures. Overall results suggest that shadow banking activities improve profit efficiency but lead to lower cost efficiency and higher risk taking. Then we investigate what influences financial deepening has had on economic growth.

Paper ID: P334
Author(s): Mehmet Sinan Iyisoy
Title: **Assessing efficiency in different departments of a hospital using data envelopment analysis**

Abstract: In this study, we compare different departments of a local university hospital located in Konya, Turkey in terms of operational and economic efficiency. We analyse hospital data that belongs to 2 fiscal years. We divide hospital departments into two groups being as operational and non-operational and compare departments within those groups. We also make an analysis using all departments together. Bed utilization in different departments is analysed using Pabon Lasso diagrams.

Paper ID: P336
Author(s): Vincent Charles and Juan Aparicio
Title: **Assessing the ease of doing business across economies**

Abstract: There is a prevalent concern nowadays as to what should prevail in deciding the country destination for doing business, apart from monetary benefits. To this aim, the purpose of the present article is to categorise the world economies according to the outcomes achieved in the various factors that define the ease of doing business index (EDBI). The present article builds upon the results from the doing business report (DBR) elaborated by the World Bank Group and other relevant professional sources. Nevertheless, whereas the DBR follows an equal weight methodology with an absolute measurement technique, the present article uses a pure DEA approach to overcome these setbacks and derive the EDBI. We then

use the EDBIs produced for every economy to assess the dynamics of the scores over a period of time. We further compare and contrast the derived EDBIs with other indices, such as competitiveness, country risk, and happiness index, through machine learning techniques.

Paper ID: P337
Author(s): Mária Trnovská and Margaréta Halická
Title: **Semidefinite programming approach to the hyperbolic measure model in DEA**

Abstract: Hyperbolic model is one of the DEA models used mainly in environmental applications. It is a non-linear model that radially decreases the inputs and increases the outputs using a single parameter. In the case of constant returns to scale (CRS) it can be transformed to a linear problem and therefore has been applied only under CRS assumption. In this presentation we show how to use this model and its modifications disregarding the type of the returns. We formulate the model as a semidefinite programming problem (SDP) that can be solved via standard convex solvers. The SDP formulation also allows the derivation of the corresponding dual model. We provide the interpretation of the dual model and illustrate the features on an example with undesirable outputs.

Paper ID: P338
Author(s): Philipp Schaper and Martin Eling
Title: **Cyclicity and productivity in the German property/liability insurance industry: Empirical evidence for 1957–2015**

Abstract: Underwriting cycles represent cyclical patterns in prices and profits in the insurance industry. Our goal is to analyse the links between the underwriting cycle and productivity in the German property/liability insurance sector. We obtained a long time series of cross sectional data for 1957–2015 through a large archival research which enables us to focus on the development of firm productivity during hard and soft market phases. In addition, we explore whether the cyclicity in prices and profits moves together with cyclicity in productivity.

Paper ID: P339
Author(s): Jiri Franek and Mehdi Toloo
Title: **A two-stage DEA approach to analysis of economies of scope: Case of China Mobile**

Abstract: Determining efficiency score and inefficiency resources is an important matter for managers and investors of different production systems in order to improve the performance of the systems. Production systems with network structures are the ones which are composed by some processes with the interrelationship. There are two basic structures for network systems which are named series and parallel ones introduced by Kao (2009), respectively. Some of the industries like telecommunications have witnessed an enormous growth since the beginning of the millennium. Though, it is similarly interesting to investigate the relationship between the growth and efficiency. This needs a more detailed analysis including measurement of the growth and changes in the effectiveness. This paper is focused on investigation of China Mobile, largest mobile telecommunications company by market capitalization today. We can investigate its growth from 2002 till 2016 with regard to the telecommunication services together with its growth as a company. However, this is a special case the analysis using two-stage DEA approach will reveal the relationship between raising economies of scope and its efficiency.

Paper ID: P341
Author(s): Lei Chen
Title: **The efficiency of provincial medical care services in China - An application of data envelopment analysis**

Abstract: Based on the medical & health data of 31 provincial districts in mainland China published by China Health Statistics Yearbook in 2015, we study the efficiency of medical and health services among residents in different provincial districts and the external factors influencing these medical efficiencies. We consider the average life expectancy and the perinatal survival rate as the two outputs of a region's health & medical services, and the region's annual per capita medical expenditure, the number of health workers per one thousand residents, the number of hospital beds per one thousand residents as the three outputs of health & medical services in the region. We use the output-oriented CRS data envelopment analysis model to analyse the efficiency of health & medical services in various regions.

The result shows that, among the 31 provincial districts in mainland China, only Anhui, Jiangxi, Hainan, and Xizang reach the efficiency of 100%. The average efficiency among these 31 provincial districts is 85.1%. We further use the second-stage linear regression analysis model to study the external causes of the variation in efficiency across regions.

Paper ID: P342
Author(s): Wenxue Tu
Title: **The historical evolution of urban space in major cities of Hubei Province and its application using DEA**

Abstract: With the development of new urbanization in China, the total urban population has been increasing dramatically. It is of great practical significance to correctly understand and accurately measure the efficiency of urban infrastructure construction. This paper discusses the problems in the construction of urban infrastructure in Hubei Province from the perspective of efficiency, and uses the DEA method and Malmquist index to evaluate the growth of urban infrastructure construction in Hubei Province. The construction of new urban areas is of great significance to solving metropolis malaise and promoting the collaborative development of cities in Hubei Province. By exploring new town's connotation and its function and mechanism, we show that modern city construction should be holistic and hierarchical. From a broad sense, it should reflect the level of modern development, with a high degree of internationalization, and be well integrated of industry and city and focus on scientific positioning.

Paper ID: P343
Author(s): Joshua Ignatius and Mohammadreza Ghasemi
Title: **Improving discriminant power of VRS by fuzzy concept**

Abstract: Lack of discriminant in efficiency values remain a major contention in data envelopment analysis (DEA) literature. To overcome the discrimination power problems, a procedure for ranking efficient units; that is, the super-efficiency model was first proposed. The method enables an extreme efficient DMU to achieve an efficiency value greater than one by excluding the DMU under evaluation from the reference set in the DEA model. However,

infeasibility problems are likely to occur when considering the super-efficiency DEA model under the variable return-to-scale (VRS). To overcome the drawback, we extend the deviation variable form of classical VRS technique based on the fuzzy concept framework.

Paper ID: P344
Author(s): Hamid Nilsaz Dezfouli, Ali Mirsalehi and Aireza Masoudylir
Title: **The centralized resource allocation for enhanced ADD model**

Abstract: All inefficient decision making units (DMUs) in the data envelopment analysis (DEA) methods can be projected onto the frontier line by reducing their inputs or elevating their outputs generated by the best performers. The centralized resource allocation (CRA) is referred to as one substantial DEA model. In this study, the enhanced additive (EADD) model has been revised and adapted based on the CRA-DEA model. In details, all the DMUs are simultaneously projected onto the frontier line by merely solving one DEA model. Moreover, the reduction of aggregate input consumption and the raise of aggregate output generation are mentioned simultaneously. The proposed approach is developed to compound non--discretionary variables. The emphasis is given to the importance of the represented model by providing numerical examples and compared to the previous models.

Paper ID: P348
Author(s): Seyad Hadi Nasseri, Maryam Olfati and Mehdi Ahmadi Khatir
Title: **Fuzzy data envelopment analysis with undesirable output: A possibility approach**

Abstract: Data envelopment analysis (DEA) is a widely used technique for measuring the relative efficiencies of decision making units (DMUs) with multiple inputs and multiple outputs. However, undesirable outputs (UO) may be present in the production process which needs to be minimized. In real-world problems, the observed values of the input and output data are often vague. This paper proposes fuzzy DEA model with undesirable outputs. The extensions to the fuzzy environment sometimes may be laid to disregard some of the properties in DEA models such as linearity and feasibility. In this way, we apply a new version of

DEA-UO model according to the possibility approach to propose a linear and feasible model in deterministic form. A numerical example is presented to illustrate the features and the applicability of the proposed models.

Paper ID: P349
Author(s): Grażyna Kozuń-Cieślak
Title: **Innovation efficiency of Visegrad Group states – recommended fields for improvement**

Abstract: The term innovation was introduced in 1911 by J. Schumpeter and since then it has been continuously explored at micro, meso and macroeconomic level. In 2016 the 9th edition of the global innovation index has been published. It ranked 128 states due to their innovativeness accessed on the basis of composite indicators. GII aims to capture the multi-dimensional facets of innovation and provide the tools that can assist in tailoring policies to promote long-term output growth, improved productivity, and job growth. This study focuses on the innovative performance of 28 member states of the EU in order to evaluate the innovation efficiency of V4 states and identifying the possible fields of inefficiency. For this purpose data envelopment analysis has been applied (using GII input-output indicators). On the basis of DEA computation Hungary and the Czech Republic has been accessed as efficient states while Poland and Slovakia showed the relative inefficiency and they should strive mainly to increasing two composite indicators: Online creativity and Intangible assets. Additionally, Poland needs to improve Knowledge impact indicator.

Paper ID: P353
Author(s): Marijn Verschelde, Laurens Cherchye, Bram De Rock and Thomas Demuynck
Title: **Nonparametric production analysis with unobserved heterogeneity**

Abstract: We propose a novel nonparametric method for the identification of production functions with unobserved technological heterogeneity. We assume cost minimization as the firms' behavioural objective, and we model unobserved heterogeneity as an unobserved

productivity factor on which we condition the input demand of the observed inputs. Our model of unobserved technological differences can equivalently be represented in terms of unobserved input levels --labelled as virtual capital -- that guarantee data consistency with our behavioural assumption, and we argue that this avoids the so-called transmission bias in a natural way. Our empirical application to Belgian manufacturing data shows that our method allows for drawing strong and robust conclusions, despite its nonparametric orientation. For example, our results show how input cost shares (including virtual capital costs) vary over time and pinpoint a clear link between outsourcing and technology.

Paper ID: P354

Author(s): Seddigheh Babaee, Yongjun Shen, Elke Hermans, Mehdi Toloo, Tom Brijs and Geert Wets

Title: **A common weight multiple layer DEA approach to assess road user behaviour in Europe**

Abstract: Application of DEA for constructing composite indicators has lately received considerable attention as a powerful tool for performance evaluation, benchmarking and decision making. However, the full flexibility of DEA in selecting the weights, on the one hand, raises the issue of compensability and on the other hand, it leads to different sets of weights for DMUs, which deter the comparison among them on a common base. To overcome these shortcomings, imposing weight restrictions for the first issue and applying a common set of weights for the second one was developed in the DEA literature. However, none of the common weights approaches take the information in the layer hierarchy of indicators into account. In this paper we propose a new approach for developing an optimal set of weights to evaluate all DMUs simultaneously while taking the hierarchical structure of the indicators into account. With an improved discriminating power, it leads to composite indicator values composed of similar weights, which is essential for fair comparison of DMUs. The usefulness of the proposed model is illustrated by constructing a composite road user behaviour index for a set of European countries.

Paper ID: P355
Author(s): Hamed Abdipourvosta and Ali Mirsalehy
Title: **To set a benchmark of safety efficiency of construction contractors through data envelopment analysis**

Abstract: The aim of this study is to use data envelopment analysis (DEA) to benchmark safety efficiency of construction contractors. DEA can be described as a strong tool which is utilized for assessing the efficiency of business organizations. The suggested method is made based on real data collected from 50 construction contractors. On a scale of zero to one, DEA analysis evaluates the relative efficiency of each contractor corresponding to the remaining of the contractors in terms of safety efficiency. For inefficient contractors, DEA analysis shows quantitative management on how to convert efficient.

Paper ID: P358
Author(s): Emmanuel Kwasi Mensah and Mehdi Toloo
Title: **Robust optimisation for nonnegative decision variables: A DEA approach**

Abstract: Robust optimisation has become the state-of-the-art approach for solving linear optimisation problems with uncertain data. Under this approach, robust counterpart to prescribed uncertainty sets are constructed for general solution to corresponding uncertain linear programing. Though relatively young, the robust approach has proven to be more essential in many real-world applications. It is remarkable that in most practical problems, the variables represent physical quantities and must be nonnegative. In this paper, we propose alternative robust counterparts for nonnegative decision variables – a reduced robust approach which attempts to minimize problem complexity. As an example, the data envelopment analysis (DEA) approach which most often considers only positive variables (solutions) is analysed. In the DEA framework, first we deal with equality in the normalisation (convexity) constraint and then a robust DEA based on the reduced robust counterpart is proposed. We report numerical results which show that the proposed approach reduces significantly the computational burden for problems with nonnegative decision variables.

Paper ID: P359
Author(s): Michal Pieter
Title: **Generalizing the hybrid structure network DEA model**

Abstract: Data envelopment analysis (DEA) is a popular tool for examining the efficiency of production units; however, traditional models consider them to be closed, black-box systems. Network DEA (NDEA) allows one to capture their inner structure as a number of interacting sub-processes, modelled using a series or parallel structures. However, for more complex systems, one must sometimes consider a hybrid structure, consisting of both. Most of existing such models are created ad-hoc for a particular real world scenario. A generalized model that could be applied to an arbitrary NDEA problem would not only provide a ready-made basis for them, but would also make possible the development of general-use software, where the structure is entered by the users themselves. This paper aims to first provide an overview of both existing, single-use hybrid models and of existing research into their generalization. The main goal is to then further develop the mathematical apparatus needed to construct a generalized Hybrid structure NDEA model and if possible, to attempt construction of the model itself. Lastly, the benefits and limitations of this approach and possible further research are discussed.

Paper ID: P360
Author(s): Luka Neralic
Title: **Algorithmic approaches to sensitivity and stability analysis in data envelopment analysis**

Abstract: Sensitivity and stability analysis in Data Envelopment Analysis (DEA) for the CCR ratio model of DEA was introduced in the paper of Charnes et al. (1985). They gave sufficient conditions for an efficient Decision Making Unit (DMU) to preserve its efficiency after the perturbation of a single output (input). The results were based on the earlier work of Charnes and Cooper (1968) after noting that variations in the data for the DMU under evaluation could alter the inverse matrix used to generate solutions in the usual simplex algorithm computer codes. This work was directed to the use of algorithms that avoid the need for additional matrix inversion. Using these algorithmic approaches, the results were extended and improved in a series

of papers published by Charnes and Neralic. In this review paper algorithmic approaches to sensitivity and stability analysis in DEA are studied for the CCR model and for the Additive model of DEA. Results for different cases of perturbations of data on outputs or/and inputs are given. Also, results for the cases of arbitrary perturbations of outputs or/and of inputs of all DMUs preserving efficiency of an efficient DMU are presented.

Paper ID: P361
Author(s): Boaz Golany
Title: **Challenges and opportunities in measuring efficiency through DEA**

Abstract: Since its inception in 1978, DEA has encountered various forces that opposed its adoption both as a valid theoretical model and as a practical tool that can be implemented in various environments. First, it was rejected by Economists who refused to accept it to their journals. It then penetrated the OR literature but in recent years it is hardly present in flagship OR journals. Numerous attempts were made to implement it in different fields. Most of them didn't last long. These implementations encountered opposition from the entities they were trying to measure and others who were responsible to monitor these entities. The lecture will discuss some of these challenges and suggest ways to address them. As well, it will also touch on the possible benefits that the current big-data revolution may bring to facilitate DEA-based efficiency measurements.

Paper ID: P362
Author(s): Fred Phillips
Title: **Personal recollections of Abraham Charnes and the early years of DEA**

Abstract: I first met Abraham Charnes at the age of 15, enrolled at the University of Texas at Austin due to Charnes' influence, became Charnes' PhD student, continued to work with him in the years he consulted for Market Research Corporation of America, and upon my return to academe, became Associate Director of Charnes' Center for Cybernetic Studies. The President of MRCA was intrigued by DEA, and together we developer the first for-profit appli-

cations, and the first parallel-processing computations for DEA. The talk will recap a perspective on DEA I published in 2005 (upon the 25th anniversary of its invention) in International Journal of Information Technology and Decision Making.

Paper ID: P363
Author(s): John Semple
Title: **Abraham Charnes and sensitivity analysis in DEA**

Abstract: The first ten years of DEA research saw many new models for measuring performance and efficiency of individual production units. With the new models came the need to measure the stability (or robustness) of their efficiency classifications with respect to changes in the data. Multiple ideas were proposed, many of which were done in collaboration with Abraham Charnes. We will discuss some of the history behind these models and how Dr. Charnes guided their intellectual development.

Paper ID: P364
Author(s): Christopher F. Parmeter
Title: **Improved data-driven smoothed DEA**

Abstract: Recent advances in kernel smoothing are applied to constrained frontier methods. This produces a smooth DEA estimator for which calculation of elasticities are easy and direct. Further, the new estimator uses a different criterion for selecting the constraint weights and the optimal bandwidth, making the estimator fully data- driven. Both simulations and an empirical application show the promise of the method.

Paper ID: P365
Author(s): Ole Bent Olesen and John Ruggiero
Title: **An improved Afriat-Diewert-Parkan nonparametric production function estimator**

Abstract: Recent developments in the production frontier literature include nonparametric estimators with shape constraints. A few of these estimators rely on the Afriat inequalities to provide piecewise linear approximations to the production function/frontier. We show in this paper

that these Afriat- Diewert- Parkan (ADP) estimators have deficiencies in the presence of moderate statistical noise including overfitting and a relatively high variance of the estimator. We propose new estimators with lower variance and a relatively low bias. We consider such alternative estimators based on (weighted) averages of random hinge functions with parameter restrictions. Small sample properties of the estimators are presented that show our new estimators outperform the existing ADP estimators when moderate to large amounts of noise are present.

Paper ID: P366
Author(s): Samah Jradi and John Ruggiero
Title: **Stochastic DEA: Measuring the production frontier in a composed error model**

Abstract: Data Envelopment Analysis was developed as a deterministic model that assumed that deviations from the production frontier were one sided representing technical inefficiency. The model provides biased estimates of production and inefficiency if deviations from the frontier arise not only from inefficiency but also from statistical noise. Banker (1988) extended Data Envelopment Analysis with a stochastic model to allow not only inefficiency but also statistical noise. Banker's model can be considered a nonparametric quantile regression. Using the celebrated Afriat constraints, the model estimates a piecewise linear production function through the middle of the data. In this paper, we extend Banker's Stochastic DEA model by identifying the most likely quantile based on assumptions of the composed error terms. Using simulated data, we compare the model to the econometric stochastic frontier model under different distributional assumptions.