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# Book of Abstracts

14<sup>th</sup> International Conference on  
Data Envelopment Analysis,  
Wuhan, China, May 23 to 26, 2016

**iDEAs**

14<sup>th</sup> International Conference on Data Envelopment Analysis

Jiangnan University, Wuhan, China, May 23-26, 2016

# Book of Abstracts



14<sup>th</sup> International Conference on Data Envelopment  
Analysis, Wuhan, China, May 23 to 26, 2016

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# Book of Abstracts

## DEA2016-P002

### How healthful was the expansion of the Private Medical Expenses Insurance in Mexico

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In the context of the outstanding growth of the accident and health insurance premiums in Mexico, partially boosted by fiscal incentives, this research evaluates the quality of the expansion. The question to answer is if productivity gains were part of the strategy of insurance companies in order to increase their market share of the growing demand. Life and Mixed groups of insurance companies were analyzed by examining data exclusively related to accident and health products. The distance between the performance of each company and the cost frontier was measured applying a model based on DEA with undesirable outputs. This model splits cost variances into cost efficiency, technology, radial activity and output mix effects measured per company in monetary terms. Final results will show the financial and economic performance of each group and point out which companies stand out from the rest. One implication of the results is that the Mexican society might have borne the costs of firms that operate below their production possibilities.

## DEA2016-P003

### An Integrated Approach of Data Envelopment Analysis and Boosted Generalized Linear Mixed Models for Efficiency Assessment

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Performance evaluation is an important part in the management of any decision making unit (DMU) as it identifies the source of managerial inefficiencies and provides a policy for inefficient DMUs to improve their efficiency. Investigating the role of environmental variables become very crucial in the overall performance evaluation. Modeling the impact of the environmental variables is a critical issue for both researchers and practitioners. Researchers developed and proposed several methods to deal with this issue in general and in the data envelopment analysis (DEA) literature in particular. However, the available two stage DEA methods don't account for interdependence between observations and they would be of limited use when the number of variables is fairly large. This paper proposes an integrated frame combining data envelopment analysis, generalized linear mixed models (GLMMs) and boosting GLMMs to account for the dependency problem in modeling the impact of environment variables on performance. The framework is illustrated with a sample of 151 commercial banks from Middle East and North African countries.

## DEA2016-P005

### **Social and Technical Efficiency of Savings Groups in Ethiopia and Tanzania**

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Traditionally the performance of microfinance industry has been highly contested both in theory and practice. Despite the existing concern on the performance and sustainability of microfinance during the past five years, the world has witnessed exponential growth of savings-led microfinance commonly known as Savings Groups as the financial vehicle for the poor mainly in Sub Saharan Africa. Whether the emerging new vehicle (saving groups) in the microfinance industry makes a difference in terms of performance and sustainability remains grossly under-explored. To address this knowledge gap, this study examines the financial and social efficiency of savings groups in order to capture the double bottom line nature of microfinance promise in performance evaluation. A two stage Data Envelopment Analysis (DEA) approach is employed to analyze the data. The first stage is used to generate the efficiency scores and in the second stage multiple regression analysis is used to identify important factors that contributes to social and financial efficiency. The study used 340 observations based on the quarterly panel data from Saving Groups operating in Eastern and Southern Africa between, 2010-2015.

## DEA2016-P006

### **Empirical Analysis of Railway Efficiency in Pakistan**

**Nadia Tahir**

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Planning Commission of Pakistan, Pakistan

This paper uses Data Envelopment Analysis model of output maximization to understand the crisis of Pakistan Railway. Performance is analyzed to identify production and allocative inefficiencies in a holistic framework. It became financially inefficient from 1985 onwards. Fewer and redundant inputs had to be used to perform service delivery which caused product inefficiency. Rising expenditures increased cost of operations which became the source of allocative inefficiency. Both resulted in train closures and shrinking business. The main policy implication is that steady investment under an autonomous and professional management is required for a turn around.

## DEA2016-P008

### **Carbon Emission in the European Union Agriculture: Driving Forces and Possibilities for Reduction**

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This paper analyses the main drivers behind energy-related CO<sub>2</sub> emission across agricultural sectors of European countries. The analysis is based on the aggregate data from the World Input-Output Database. The two main directions are taken for the research. Firstly, Index Decomposition Analysis is facilitated by the means of Shapley index to identify the main drivers of carbon emission. Secondly, the Slack-Based Model is applied to gauge the environmental efficiency of European agricultural sectors. By applying frontier techniques, we also derive the measures of environmental efficiency and shadow prices. The research covers eighteen European countries. The lowest carbon shadow prices are observed in France, Finland, Sweden, Denmark, the Netherlands, Poland, and Belgium. These countries, thus, feature the highest potential for reduction in carbon emission.

## DEA2016-P009

### **Title: The Determinants of Efficiency in Manufacturing Industries in Lao PDR**

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There are three main objectives of the study, estimating the efficiency of firms in manufacturing in the Lao PDR, especially food, beverage, wood processing and garment sectors; finding out some factors affecting on technical inefficiency of firms in manufacturing in the Lao PDR such as food, beverage, wood processing and garment sectors and comparing the efficiency among food, beverage, wood processing and garment sectors in the Lao PDR. This study will employ a stochastic frontier production function to measure the technical efficiency of manufacturing output in Lao PDR. This paper will devote the stochastic frontier production function technique to assess the technical efficiency of manufacturing industry, in particular, the Cobb-Douglas stochastic frontier production with the distributional assumption. Since the cross sectional data is used in this study, firm survey is needed. The Lao PDR became a full member of ASEAN and joined the ASEAN Free Trade Area (AFTA) in 1997 and also a member of World Trade Organization (WTO). These phenomenon's will provide increased access opportunities for Lao manufacturing sector to export more, considering the potential contribution that the manufacturing sector has to drive the development of Lao economy and the high competition with the world market, exploring an efficiency of Lao manufacturing sector and some other factors affecting to the sector are the most significant for assisting the government of Laos to develop an appropriate policies.

## DEA2016-P011

### **Evaluating productive efficiency of pollution-generating processes: review of theories and applications**

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Nanyang Technological University, Singapore

We review more than three-hundred journal papers and provide an up-to-date review of DEA models and applications regarding pollution-generating processes (PGP). The PGP that we consider include processes in which either undesirable outputs or desirable inputs are involved. We cover a variety of application areas and industry contexts. We conclude this study with a broad suggestion about future research opportunities.

## DEA2016-P014

### **Dynamic network DEA model for a two-stage system with intertemporal shared outputs: an application to Chinese high-tech activities**

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Dynamic network DEA have received much attentions from researcher to evaluate the performance of a system during a long-term production. However, rare work considers the issue of shared outputs which are caused by lagged production effect of inputs. To address this issue, a dynamic two-stage network approach is proposed for measuring the efficiency of a system with two-stage structure and shared outputs. Then, this approach is applied to the high-tech activities in Chinese provinces. We divide the high-tech activity system into two stages: technology research and development stage, technology digestion and absorption stage where the intertemporal shared outputs exist. The empirical results by our approach indicated that Chinese high-tech activities had more weakness in technology digestion and absorption. Finally, some suggestions are given for improving the overall efficiency of high-tech activity.

## DEA2016-P016

### Star Structure in Network Data Envelopment Analysis

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Data Envelopment Analysis (DEA) is a method based on linear programming to measure efficiency of Decision Making Units (DMU). In classic models of Data Envelopment Analysis, the whole system had been usually considered as a Decision Making Units to evaluate respective efficiency and it is also ignored the separate processes inside the system. Whereas, the internal relations of various sectors of a Decision Making Units can have had diverse structures which cause complexity in evaluating of its efficiency. It is because, the type of structures and the performance of these components would have different effects on efficiency of the system. Network standpoint is one of the appropriate ways for the internal relations of units' modeling and the relation among sub-units in a DMU may be communicated in series, parallel or mixed way. In this paper, a new structure called Star Structure was introduced as a comprehensive one. The one that every structure existing between a Decision Making Units' sub-units can easily be converted to such structure so that can accurately evaluate a Decision Making Units' efficiency and also using star structure, we evaluated the performance of regional electronic companies in Iran.

## DEA2016-P017

### Recognizing directional congestion in integer-valued DEA

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Congestion is a special phenomenon in the production process that reducing one (or more) input(s) can increase one (or more) output(s). In this vein, Yang et al. (2014) presented a DEA approach to analyze the effect of directional congestion to the right and left of decision making units (DMUs). However, their congestion approach assumes all inputs and outputs of DMUs to be continuous and non-negative while, in the real world, some inputs and/or outputs can only take integer values. This fact is the motivation for creating this current research. To tackle this drawback, this study proposes an integer-valued DEA approach based on the slack variables for recognizing the right- and left-hand directional congestion status in the presence of both continuous and integer data. Thus, this paper incorporates the implication of directional congestion into the integer-valued DEA. Lastly, the geometric interpretation of the proposed congestion approach and a numerical example are provided to illustrate the purpose of this research.

## DEA2016-P018

### **Dynamic returns to scale and most productive scale size in DEA with negative data**

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Non-parametric evaluation of returns to scale of production units in standard DEA models becomes problematic when their underlying technologies involve both positive and negative data. The methodology recently offered by Allahyar and Rostamy-Malkhalifeh (2015) (hence after called ARM model) is of some help to deal with this issue. However, there are two shortcomings underlying the ARM model. First, it may not be capable of locating all the production units exhibiting constant returns to scale; and second, it is also not able to determine most productive scale size. In order to deal with these shortcomings, the current paper contributes to the DEA literature in two ways. First, it makes a unifying attempt to propose a general non-radial DEA model to determine both the most productive scale size and the returns to scale classifications of production units in the presence of negative data. Second, the proposed model can be adapted in a dynamic DEA technology setting to determine growth efficiency and returns to growth behavior of high-technology production units facing hyper competition in a new economy.

## DEA2016-P020

### **Efficiency contribution patterns in Chinese commercial banks**

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Apart from conventional DEA-based efficiency method which is self-evaluated to assess individual firm's efficiency, in this paper, we employ a new method which is based on each firm's marginal contribution to its technical efficiency and overcomes several drawbacks in standard DEA method to re-evaluate, not only levels, but also patterns, of efficiency contribution in Chinese commercial banks. Specifically, we extend initial efficiency contribution method with respect to a disaggregation into input and output specific efficiency contribution. We take large state-owned commercial banks and small-medium commercial banks in China into account, and are able to empirically test efficiency contribution gap in both levels and patterns between the two types of banks. Due to specific input and output efficiency contribution, we further explore the source of efficiency contribution, and target for structure optimization in the Chinese banking sector. Moreover, there are arguable differences between standard DEA-based efficiency score and various efficiency contribution indicators, but we find reasonable supports for the latter one according to key performance indicators.

## DEA2016-P022

**New super efficiency method based on a modification of the Enhanced Russell model**

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In this paper, we show that the Enhanced Russell model (ERM) failed to present a complete ranking for DMUs. Then, we propose a modification of Enhanced Russell model such that the new modified model is able to present a complete ranking and also preserve the properties of the ERM.

## DEA2016-P023

**Setting handicaps to industrial sectors in DEA illustrated by Ethiopian industry**

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In the ordinary macro-economic input-output tables, the industrial sector consists of several dozen industries and each industry in a certain sector is an aggregate of many companies in the sector. The sectoral statistics are the sum of statistics of companies in the respective sector. Usually, all sectors have the same set of inputs for producing outputs. For example, they have labor, capital and intermediate as input and amount of production as output. We can apply traditional DEA models for evaluation of efficiency regarding all sectors by means of these common input and output factors. However, there remain some insecure feelings in

comparing all sectors as a scratch race. Some sectors are in fields with matured technologies, while others are in emerging fields. Some are labor intensive, while others are capital intensive. These situations lead us to compare sectors under a handicap race. In this paper, we propose a new DEA model based on the non-convex frontiers that all associated sectors may exhibit and handicaps are derived from. We apply this model to Ethiopian industry.

## DEA2016-P024

### **Cost minimizing target setting onto the Pareto-efficient frontier in DEA: A mixed integer linear programming approach**

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We consider cost minimizing target setting problem in DEA, assuming that marginal costs of reducing inputs or increasing outputs are known. We extend the problem to an non-oriented VRS DEA model and build a mixed integer linear programming to solve it. Some experiments with simulated datasets are conducted to evaluate our approach.

## DEA2016-P025

### **Regional energy efficiency evaluation using two-stage, semi-parametric models and bootstrap technology**

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With the increasing consciousness about the environmental problems, the eco-efficiency has received growing attention from policymakers, researchers and practitioners. Research associated with the impact of contextual variables on eco-efficiency has also received considerable academic interest and the regression techniques have been applied to assess the effects of contextual variables. The approach of combining the DEA method and regression techniques is called a two-stage approach and is advocated by a number of researchers. This paper first uses two-stage approach with bootstrap technique to analyze the eco-efficiency

of 29 regions of China between 2000 and 2013. And the two-stage bootstrap technique is used to analyze impacts of environmental factors. Research results show that the eco-inefficiency is underestimated by the conventional approach, while the bias can be rectified by the proposed algorithm. The research also finds that in addition to environment management variables, other factors including foreign direct investment, industrial structure and human capital, which are not detected by the conventional approach, all have significant effect on eco-inefficiency.

## DEA2016-P026

### **Eco-efficiency considering CO2 emissions and data envelopment analysis: A structured literature review**

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This work aims to conduct a structured literature review on the research works which have used the data envelopment analysis (DEA) (including Malmquist-Luenberger productivity index (MLPI)) to measure the efficiency and productivity of decision-making units (DMUs) with CO2 emissions as the undesirable outputs. We research into Web of Science (WoS) academic database and developed a sample of 171 papers published between 1989 and 2015. We apply a structured literature research and a citation network analysis to show the evolution of literatures in this research topic. In doing so, we (a) examine the key-route main path of knowledge flows characterizing the topic researched, (b) provide basic bibliometric information about the most active journals and authors, (c) conduct a qualitative in-depth analysis of the identified most important studied and (d) focusing on the most recent period between 2000 and 2015, identify the research fronts and relate them to the emerging issues on the topic researched. In particular, we conduct in-depth analysis of the papers on the key-route main path we discovered using bibliometric methods.

## DEA2016-P029

### **Technical efficiency of public insurance health centers in Gezira State of Sudan**

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This study aimed to measure the technical efficiency of 31 direct and 57 indirect insurance public primary health centers in Gezira State of Sudan and to identify the possible factors affecting their technical inefficiency. In the first stage, an input orientated data envelopment analysis was adopted to compute the technical efficiency scores for both types of health centers. In the second stage Tobit model was used to

determine the factors that affect technical inefficiency of the health centers. The study revealed that the average technical efficiency score of both direct and indirect health centers was 77%. The results also showed that 45.4% of direct and 43.9% of indirect health centers were run inefficiently. From the results of Tobit regression, being direct health center, large size and large center in urban were found to be significant and negatively affecting the technical inefficiency. Being in urban, high ratio of medical to non-medical staff, the size in form of square and the time dummy variable for year 2012 significantly increased the technical inefficiency of the health center.

## DEA2016-P032

### **Emissions trading and abatement cost savings in China's thermal power industry**

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This study evaluates, by utilizing a DEA based model, the efficiency advantage of a market-based emission permit trading policy instrument over a command and control policy instrument for emission control in China's thermal power industry from the perspective of estimating the unrealized gains achievable through emission permit trading. These unrealized gains represent the potential recoveries of electricity generation loss (caused by emission abatement activities) through eliminating spatial and temporal regulatory rigidity on emission permit trading. The results of an ex post estimation for the thermal power industry sectors of China's 30 regions indicate a potential 8.48% increase in electricity generation if both the intra- and inter-period allocation inefficiency of CO<sub>2</sub> emission permits had been eliminated through spatial and temporal CO<sub>2</sub> emission permit trading.

## DEA2016-P035

## DEA2016-P036

### **The "weak link" approach to network DEA: The case of two-stage processes**

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Network DEA is an extension of conventional DEA developed to take account of the internal structure of the decision making units (DMU). In network DEA, the DMU is considered as a network of interconnected sub-units (commonly called stages, divisions, sub-processes), with the connections indicating the flow of intermediate measures. The multiplicative decomposition approach and the additive decomposition approach are the first methods to assess the stage efficiencies and the overall system efficiency jointly in one

program. In this paper, we introduce a novel definition of the system efficiency in two-stage processes, inspired by the “weak link” notion in supply chains and the maximum-flow/minimum-cut problem in networks. Adapting the above notion to fit the multistage processes dealt with in network DEA, we develop a max-min optimization model to estimate the stage efficiencies and the overall efficiency in a multi-objective programming setting.

## DEA2016-P037

### **Abatement costs of Emissions from Crop Residue Burning in major crop producing regions of China: Using a DEA method**

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China being an agriculture-dominant country produces more than 800 million tons of crop residues annually. Some residues are used as animal feed and domestic fuel, while a large portion of unused crop residues are burnt in fields primarily to clear the left-over straw and stubbles after the harvest. This paper is to estimate abatement costs of burning crop residues in terms of crop production loss. Policy makers can use them as a reference to decide on whether to take a new technology in reducing emissions from crop residues or reduce emissions by planting less crops given current technology. If this abatement cost is highly than some other utilization of crop residues, e.g. producing biofuel using crop residue, then building a biofuel company should be chosen rather than reduce crop residue burning through reducing crop production. Otherwise, reducing emissions will be achieved through reduction of crop production.

## DEA2016-P040

### **Allocation of potential cooperative gains based on efficiency analysis**

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Most traditional data envelopment analysis (DEA) models concentrate on one DMU's efficiency evaluation and improvement. In these models, resources and information of each DMU are independent. The purpose of this paper is to relax the assumption of independent DMU, we assume that DMUs can cooperate with each other to share resources and information. We estimate the potential gains from three cases of cooperation, and then, allocate the cooperative gains to each DMU in the coalition. The conception of Production

Possibility Set (PPS) from Data Envelopment Analysis (DEA) literatures is applied to evaluate the potential cooperative outputs. A Nash bargaining game model is developed for a fairness allocation. The developed models are applied to a numerical example of Chinese City Commercial Banks (CCCBs).

## DEA2016-P043

### Developing a Model for Determining Corporate Performance after Bank Acquisition

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This is a panel study to model bank performance after acquisition. Value Added Approach of DEA with CRS and VRS models employed to determine efficiency of banks. Sixty-two banks divided into large and small, acquired in 2006 which had data with Fitch/IBCA/Bureau Van Dijk Bankscope database were studied from 2007-2012. Results from the VRS model were used for further analyses whilst Malmquist TFP identified key value drivers in the acquired banks. Five environmental variables: Corruption Perception Index (CPI), Bank Industry Concentration (BIC), Total Assets, Gross Domestic Product (GDP) and Real Interest Rates (RIR) were regressed on efficiency scores using fractional regression models to determine their impact on efficiency. The "Spearman rho" correlation between efficiency and profitability ratios was established.

## DEA2016-P046

### Allocation of emission permits based on DEA and production stability

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Allocation of emission permits (AEP) is the core issue of emission trading system (ETS). The allocation scheme based on data envelopment analysis (DEA) can make all decision making units (DMUs) efficient or Pareto efficient after allocating. With considering the concept of production stability, this paper proposes a novel DEA model for AEP to generate a unique allocation scheme. Comparing with the existing approaches,

including the approach of maximizing satisfaction degree in Li et al. (2013), the proposed model provides a more practicable allocation scheme to satisfy production needs. Finally, the novel approach is applied to the dataset of sulfur dioxide emissions from 31 provinces in China.

## DEA2016-P047

### **An extension on super slacks-based measure approach**

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Recently, a slacks-based version of the super slacks-based measure (S-SBM) is developed and a novel two-stage approach is proposed to calculate both super-efficiency score by the S-SBM model and efficiency score by the slacks-based measure (SBM) model. In this paper, we extend the approach to consider continuity of efficiency scores. We illustrate the discontinuity of efficiency measure, then define a continuous slacks-based measure (CSBM) which is proved continuous and directly calculated. An interesting efficiency zone category is also provided. In addition, this paper has investigated the relationship among the super-efficiency measures of the proposed approach in this paper and some existing approaches under variable returns to scale (VRS).

## DEA2016-P050

### **Empirical Research on the Effect of Industrial Structure on Energy Efficiency in 21 districts of Sichuan Province**

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The research takes the energy efficiency problem, which is widely concerned by domestic and foreign scholars, as the research object. It uses the data envelopment analysis method to study the effect of industrial structure on energy efficiency from the angle of output structure. The research uses the Output Structure Efficiency Evaluation Model of Energy and the Output Structure Efficiency Change Index Evaluation Model of Energy to study the energy efficiency. Under the comparison the industry structure efficiency of energy of Sichuan Province with the National and Western region, it does the comparative study and analysis about the

effect of industrial structure on energy efficiency between the 21 districts of Sichuan Province from 2005 to 2013. It proposes suggestions to adjust and optimize the industrial structure for each district in Sichuan Province. It provides the policy suggestions and decision-making basis for the relevant government departments to formulate industrial structure optimization policy to improve energy efficiency.

## DEA2016-P051

### **An improved Afriat-Diewert-Parkan nonparametric production function estimator**

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Nonparametric regression estimators with shape constraints have recently been extended. One of these estimators denoted the naive Afriat-Diewert-Parkan (ADP) estimator relies on the so-called Afriat inequalities. We focus on overfitting of this ADP estimator and provide improvements addressing deficiencies of the estimator including: i) overfitting implies poor generalization when a moderate amount of noise is present, ii) this estimator has a relatively high variance, and iii) the ADP estimator does not take advantage of low bias of related restricted estimators with higher Mean Square Error. Overfitting of the ADP estimator suggests that estimators based on a weighted average of restricted estimators may provide an equally unbiased estimator but an estimator with lower variance. An Average Random k-Hinge (ARK-H) estimator is proposed which provides exactly an equally unbiased estimator but an estimator with lower variance. Alternatively, the Jackknife Model Average (JMA) or a slightly modified (JMA-lb) is considered. Small sample properties of the estimators are presented indicating the variance of the AR2-H estimator is lower than the ADP, the JMA and the JMA-lb estimators when moderate to high amounts of noise are present. With decreasing amount of noise the JMA and especially the JMA-lb estimator seem to outperform the other two estimators.

## DEA2016-P053

### **Benchmark Forecasting in Data Envelopment Analysis for Decision Making Units**

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The purpose of this paper is to develop a benchmark model for efficiency evaluation in future. With forecasting the efficiency of organizations, managers could plan and determine that strategy. One of the most important methods for evaluating decision making units (DMUs) is DEA. Although DEA is a powerful method in evaluating DMUs, it does have some limitations. One of the most important limitations of this method is the result of the evaluation is that the efficiency calculated was based on previously existing data and the



results are not proper for forecasting the future changes regarding inputs and outputs required for the units to be considered as efficient. The aim of this paper is to propose a model to enlighten and forecast how inputs and outputs alter through system dynamics and simulation. For this purpose, we design feedback loops for forecasting inputs and outputs. Then we use CCR model to forecast the efficiency.

## DEA2016-P055

### **Measurement of Bank Performance: A DEA Approach with Nonperforming Loans and Carryovers**

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Southeast Missouri State University, United States

We develop a dynamic-network directional distance function for banks, which face network and dynamic production systems. The network part represents a network technology where raised funds are produced as intermediate products in a first stage and then those intermediate products are utilized to generate a portfolio of assets in a second stage. The dynamic part links production periods through nonperforming loans and carryover assets which have the opposite effects on future production possibilities. Nonperforming loans reduce future production possibilities, because those nonperforming loans serve, in the first stage, as the burden stemming from previous periods. By contrast, carryover assets enhance future production possibilities because those assets from the current period become an input to the second stage in the next period. Moreover, we incorporate an existing relationship between good outputs and nonperforming loans in the dynamic-network framework. We apply this method to Japanese banks operating during the fiscal years 2007-2014.

## DEA2016-P057

### **Utilization of cross efficiency to improve efficiency under fixed input/output resources**

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In many real world applications, organizations struggle to improve the performance when inputs and outputs are exogenously fixed to a given value. In this paper, we have developed Data Envelopment Analysis models & algorithms in order to improve the efficiency of an inefficient decision making unit (DMU) under constant sum of input and output constraint. The cross efficiency approach has been utilized to identify the target DMUs to allocate the excess inputs. The excess amount is reallocated among the targeted DMUs without any reduction in their efficiency. Results have also been extended to include input/output weight restrictions. The

proposed DEA models will help the decision makers to develop an optimal strategy to reallocate input/output among DMUs without adversely affecting their performance. An application of the results has been demonstrated through an example from health sector.

## DEA2016-P058

### **Quantile-DEA Ranking Method for Multi-Attribute Decision Making Problems with Interval Data**

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In practice, decision makers very often face the problems of making preference decisions over the available alternatives that are characterized by multiple and usually conflicting attributes. In addition, it is also quite common that decision makers can only acquire imprecise data such as interval data for making their decisions, which further complicates decision making processes. Despite the practical importance of making decisions under the above setting, to our knowledge, there are a very limited number of studies addressing such decision making problems. The proposed ranking methods in the literature are basically based on the conventional approaches for Multi-Attribute Decision Making (MADM) problems with deterministic data. Hence, this research intends to develop a new ranking approach for dealing with the MADM problems with a single decision maker and interval data. The proposed approach adopts the ideas and techniques of both quantiles in statistics and data envelopment analysis (DEA), and is thus referred to as the quantile-DEA ranking method in this research. This ranking method is quite easy to implement. We apply the approach to a real-life MADM problem of evaluating banking performance to show its efficiency.

## DEA2016-P059

### **Measuring the Efficiencies of China's Grid Companies: A Bootstrapped Meta-Frontier Approach**

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China's current electricity mechanism has initially taken shape since 2003 as a result of the power reform introduced in 2002. In general, the reform has gained success in the generation sector and China has definitely solved the difficulty of power shortage in recent years. In addition, China has become the largest power

producer and consumer in the world since 2010. At the same time, the proportion of clean energy has increased rapidly, which aroused lots of transmission and distribution difficulties due to the intermittence and instability of clean energy. Although the issue of power shortage have been overcome successfully after 2009, the operation efficiency and service quality have remained to be the critical issues of the current power systems. Even though the reliability and quality of the power supply have improved a lot in the past decades, there still exist several critical issues needing to be solved in the grid industry. Such as, the coexistence of power shortage and grid unavailability in different areas, lack of improvement in establishing competitive power markets; the difficulties in operation management coming from the distorted pricing mechanism. Consequently, most of the recent policies related to the power systems focused on the grid industry. Efficiency analysis may play an important role in gauging the performance of different companies and the effects of regulatory policies. In order to provide a benchmark for the development of grid utilities, this study evaluates the operation efficiencies of 31 provincial grid companies in China from 2004 to 2013 using a bootstrapped non-parametric meta-frontier approach. The results may provide support for the smart grid construction and future power policy reforms.

## DEA2016-P060

### **Creating Competitive Advantages in Parcel Delivery Service using Data Envelopment Analysis (DEA)**

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**Ping Ji**

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In service industry, the service profit chain suggests that satisfied employee delivers great service to delight customer; leading to improved business performance through outcomes such as repurchase and advocacy driven by customer loyalty. In such a competitive business environment, the role of frontline management to work around the demanding customer, employee and shareholder has become more critical than ever. The purpose of this study is to explore how DEA could be used to evaluate the performance of frontline management to strike a balance between customer satisfaction, employee satisfaction and productivity improvement for cost control. The idea was put into practice by applying DEA to evaluate the performance of a pool of frontline supervisors in a parcel delivery service company

## DEA2016-P062

### **What kind of skilled labor does technological progress in China's manufacturing industry bias? Application of the bias-corrected Malmquist indices**

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In China's labor market, enterprises are difficult to recruit workers, and university graduates are difficult to find jobs, that is, medium-skilled labor shortage and high-skilled labor overage coexist. Biased technological progress will lead to changes in demand for different skilled labors, so this paper divides labor into low-skilled labor, medium-skilled and high-skilled labor, and adopts the bias-corrected Malmquist indices to measure the biased technological progress of China's manufacturing. The results show that technological progress of China's manufacturing biased high-skilled labor before 2006, but it biased medium-skilled labor after 2006. China's medium-skilled labor biased technological progress lead to increased demand for medium -skilled labor, which explains the reasons for structural contradictions in China's labor market from the demand angle.

## DEA2016-P063

### **Performance Measurement and Productivity Growth of Veterans Branch Hospitals in Taiwan Using DEA and BSC**

**Mei-Fang Hsu**

Fo Guang University, Taiwan

**Shinn Sun**

Fo Guang University, Taiwan

The purpose of this study is to assess overall performance and individual performances, and productivity change of the 12 selected veterans branch hospitals in Taiwan over 2010-2015. Taipei Veterans General Hospital consists of 7 branch hospitals. Taichung Veterans General Hospital consists of 3 branch hospitals. Kaohsiung Veterans General Hospital consists of 2 branch hospitals. Each branch hospital is seen as a decision making unit. This study integrates Data Envelopment Analysis (DEA) and Balanced Scorecard (BSC) approach to measure four types of individual performances in terms of financial measure, customer measure, internal business process, and learning and growth measure. The study applies output-oriented assurance region DEA to assess these four individual performances and overall performance of the 12 branch hospitals. This study employs cross efficiency measure to identify the best practices in individual and overall performances, and uses Malmquist index to estimate productivity change of the sampled branch hospitals over a six-year period. Finally, some important managerial implications and suggestions are presented.

## DEA2016-P064

### **A Centralized Dynamic Approach for Measuring the Efficiency of Cooperative Banks in Germany**

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German cooperative banks (“Volks- and Raiffeisenbanken”) are credit institutions whose aims are mainly providing financial services to the local retail customers as well as supporting small and medium-size businesses in the regions a particular bank is situated. These banks operate independently and are locally administrated by their own management boards. Furthermore, they are controlled centrally by the National Association of German Cooperative Banks. This umbrella organization is responsible for coordinating decision making within the group, determining strategic directions and making general policy decisions as well as monitoring the activities of the banks. This paper presents a centralized DEA approach for measuring the relative efficiency of a panel of the German cooperative banks over the time period 2008–2014. With respect to the centralized structure, which characterizes the group of these banks, the intermediation approach is applied to specify the inputs and outputs. Moreover, the Malmquist index and its decomposed components are analyzed in order to measure performance over time.

## DEA2016-P065

**Peer Selection in DEA – Efficiency vs. RTS****Andreas Dellnitz**

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**Elmar Reucher**

Private Hochschule für Wirtschaft und Technik Vechta, Germany

Data envelopment analysis (DEA) is a well-known method for measuring the efficiency amongst a group of decision making units (DMUs). But especially the BCC-model – named by their creators Banker, Charnes, Cooper (1984) – often will be applied to get more information about a DMU's economic position in DEA; thus one can easily obtain the DMU's Returns to Scale (RTS). This information enables the DMU to decide whether its economic activity should be up- or downsized for gaining scale-efficiency rather than improving technical efficiency. The purpose of a peer-based DEA is to find a peer – one price system that acts as a common efficiency- and RTS-denominator for all DMUs. The peer price system then might be used for further activity planning. In most applications the price system with the least efficiency deviation for all DMUs is the preferred one. Efficiency is only one economic measure, RTS is the other. In this talk we show that efficiencies and returns to scale are both appropriate indices to select a peer. However, in some cases these objectives may collide and hence we get different peers. Therefore, we present a multi-criteria optimization problem to combine both potentially conflicting criteria.

## DEA2016-P066

## **A Centralized Performance Benchmarking Approach for Maintenance Groups in the Elevator and Escalator Industry**

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KONE is one of the global leaders in the elevator and escalator industry with more than 1,000 offices in 60 countries around the world. The company provides industry-leading elevators, escalators and automatic building doors as well as innovative solutions for modernization and maintenance. In addition to these solutions, they offer a portfolio of services to support the customers – architects, consultants, builders, developers, building owners and facility managers – at every step of their building’s lifecycle, from its design and construction to its maintenance and modernization. This paper presents a centralized DEA approach for measuring the relative efficiency of KONE’s maintenance groups in Germany. This will be done by designing a goal-oriented approach by which a multi-dimensional perspective on performance is incorporated into the efficiency evaluation. The proposed perspectives represent the dual role of the maintenance groups as both providers of services to the customers and operating units which should contribute to the profit of the company as a whole. Also, a meta-frontier method is used to facilitate the comparison of the efficiency of the maintenance groups operating in different geographical locations in Germany.

## **DEA2016-P067**

### **From RTS to Cross-RTS**

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Data envelopment analysis (DEA) is a well-established instrument to detect the (in-)efficiencies and returns to scale of a certain set of decision making units (DMUs). Here for a long time the so-called self-appraisal – in which each DMU optimizes its individual weighting scheme – was the predominant approach. The derived weighting scheme then allows the user to determine both above stated indices. But what does such a scheme imply for the remaining DMUs – since they are integral part of all calculations? The first contribution, which tackles this question, is that of Sexton et al. (1986); in this paper the authors develop the cross-evaluation approach – called peer-appraisal. More precisely: each determined weighting scheme is applied to the activities of all DMUs to get their cross-efficiencies. However, as mentioned above, (cross-)efficiency is only one economic indicator. Hence it would seem natural to treat the stated question in the light of returns to scale (RTS). Consequently, in this contribution we develop a cross-evaluation approach which comprises RTS

– this leads us to the new concept of cross-returns to scale. Finally, an economic analysis of this new measure concludes this talk.

## DEA2016-P068

### **A DEA-based Incentives System for Centrally Managed Multi-Unit Organisations**

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In multi-unit organisations such as a bank and its branches or a national body delivering publicly funded health or education services through local operating units, the need arises to incentivize the units to operate efficiently. In such instances, it is generally accepted that units found to be inefficient can be encouraged to make efficiency savings. However, units which are found to be efficient need to be incentivized in a different manner. It has been suggested that efficient units could be incentivized by some reward compatible with the level to which their attainment exceeds that of the best of the rest, normally referred to as “super-efficiency”. A recent approach to this issue in the literature has used Data Envelopment Analysis (DEA) models to measure the “super-efficiency” of the whole system of operating units with and without the involvement of each unit in turn in order to provide incentives. We identify shortcomings in this approach and use it as a starting point to develop a new DEA-based system for incentivizing operating units to operate efficiently for the benefit of the aggregate system of units. Data from a small German retail bank is used to illustrate our method.

## DEA2016-P069

### **DEA-based activity planning with information asymmetry under different production technologies**

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Data envelopment analysis (DEA) has been extended from the ex post diagnostic analyses to ex ante planning function. Many DEA-based activity planning models, e.g., resource allocation and target setting models have been proposed in the literature. Bogetoft (2000) studied how DEA can support activity planning under asymmetric information and strategic behavior. In the current paper, we extend the analysis to different production technologies. We present a new analytical framework (a pricing approach) which is distinct from Bogetoft (2000). Specifically, we estimate the cost requirement for decentralized two-level activity planning

problems under voluntary compliance regime. We find that the DEA estimated cost under constant returns to scale (CRS) assumption for implementing a specific production plan is incentive compatible, which is consistent with Bogetoft (2000); however, under non-increasing returns to scale (NIRS) assumption, the DEA based cost estimate is not. Nevertheless, the incentive compatibility can be recovered by adding an extra amount to the DEA based cost estimation. An illustrative application is used to show the applicability of the method developed to assist the resource allocation process.

## DEA2016-P071

### **Productivity Assessment of Petrochemical Industry in Taiwan Using Data Envelopment Analysis and Balanced Scorecard Approach**

**Shinn Sun**

Fo Guang University, Taiwan

**Chih-Wei Feng**

Fo Guang University, Taiwan

The purpose of this study is to assess the productivity, productivity change of petrochemical industry in Taiwan over 2004-2013 and examine the effects of environmental factors on the overall productivity of the surveyed industry. This study will select 20 firms as decision making units. These 17 firms are listed at stock exchange and 3 initial public offerings (IPO) petrochemical-related firms. This study will use weighted slacks based measures (WSBM) data envelopment analysis combined with the balanced scorecard (BSC) to assess overall productivity (OP) and individual productivities: financial perspective (FP), customer perspective (CP), learning and growth perspective (LGP), internal process perspective (IPP) of petrochemical industry, employ cross efficiency measure to identify the best practice, utilize Malmquist productivity index (MPI) to estimate productivity change over a ten-year period, and apply Tobit regression analysis to examine the effects of environmental factors on the overall productivity of the surveyed industry. Finally, some important managerial implications and suggestions are presented.

## DEA2016-P073

### **Performance Measurement and Productivity Growth of Hemodialysis Rooms of Veterans Branch Hospitals in Taiwan Using DEA and BSC**

**Fu-Fen Li**

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**Shinn Sun**

Fo Guang University, Taiwan

The purpose of this study is to assess overall performance and individual performances, and productivity change of the 12 selected hemodialysis rooms (HDRs) of veterans branch hospitals in Taiwan over 2010-2015. Taipei Veterans General Hospital consists of 7 branch hospitals. Taichung Veterans General Hospital consists of 2 branch hospitals. Kaohsiung Veterans General Hospital consists of 3 branch hospitals. Each branch



hospital operates a HDR that is seen as a decision making unit. This study integrated Data Envelopment Analysis (DEA) and Balanced Scorecard (BSC) approach to measure four types of individual performances in terms of financial measure, customer measure, internal business process, and learning and growth measure. The study applied output-oriented assurance region DEA to assess these four individual performances and overall performance of the 12 HDRs. This study employed cross efficiency measure to identify the best practices in individual and overall performances, and used a DEA-based Malmquist index to estimate productivity change of the sampled HDRs over a six-year period. Finally, some important managerial implications and suggestions are presented.

## DEA2016-P074

### **Evaluation and Selection of Domestic Pharmaceutical Suppliers for Yuli Psychiatric Hospital in Eastern Taiwan Using DEA and AHP**

**Hsin-Yi Tsai**

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**Shinn Sun**

Fo Guang University, Taiwan

The purpose of this study is two folds: to evaluate the business performance of top 20 domestic pharmaceutical suppliers and to select the best supplier from a list of potential suppliers for a mental specialized hospital in terms of their business performance. To test Data Envelop Analysis (DEA) and Analytic Hierarchy Process (AHP) in practice, cooperation was established with case study hospital (Yuli Psychiatric Hospital in Eastern Taiwan), which is providing many inpatients and outpatients with a large amount of psychiatric medicines. The study applied output-oriented assurance region DEA to evaluate the 20 sampled pharmaceutical suppliers with multiple business operating inputs and outputs. We identified a list of potential suppliers by their efficiency scores of one. This study employed AHP to select the best suppliers by taking into account of multiple criteria (e.g. quality, flexibility, reposefulness, and cost) from a buyer perspective. Finally, some important managerial implications and suggestions are presented.

## DEA2016-P075

### **Assessing Performance and Productivity Growth of Veterans Medical Beauty Centres in Taiwan Using DEA and BSC**

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**Shinn Sun**

Fo Guang University, Taiwan

The purpose of this study is to assess overall performance and individual performances, and productivity change of the 8 selected veterans medical beauty centers of Verans General Hospitals in Taiwan over 2010-2015. The 8 sampled centers are collected from Taipei, Taichung, and Kaohsiung Veterans General Hospitals.

A mission of a veterans medical beauty center is to support the healthy transformation of a customer's body, mind and spirit by offering beauty services for hair, skin and nails. Each medical beauty center is seen as a decision making unit. This study integrates Data Envelopment Analysis (DEA) and Balanced Scorecard (BSC) approach to measure four types of individual performances in terms of financial measure, customer measure, internal business process, and learning and growth measure. The study applies output-oriented assurance region DEA to assess these four individual performances and overall performance of the 8 centers. This study employs cross efficiency measure to identify the best practices in individual and overall performances, and uses Malmquist index to estimate productivity change of the sampled centers over a six-year period. Finally, some important managerial implications and suggestions are presented.

## DEA2016-P076

### **A Scale-Efficiency Matrix and Application on Evaluating Big and Strong Enterprises**

**Nan Zhu**

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**Wei Wei**

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**Dan Yang**

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This paper provides a scale-efficiency matrix to evaluate the operation scale and efficiency of general enterprises by using the evaluation method of Fortune Global 500 and Data Envelopment Analysis (DEA) method. The matrix can be used to evaluate the competitive power regarding as "big and strong" of the enterprises. As a real application, Chinese feed listed companies, which belong to one kind of special manufacturing industry, are discussed. Strategy routes for the relevant backward companies to raise their competitive power are provided.

## DEA2016-P081

### **Three equitable resource allocation methods using data envelopment analysis**

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In this paper, three methods are proposed for fair allocating fixed resources between "n" Decision Making Units (DMUs). These three approaches actually are three parts of a three-stage algorithm. In each stage of

this algorithm a method is presented for resource allocation and moreover the proposed method in the second stage is more equitable than first stage and the third one is more fair than second, too. In fact, in second and third stages the former method is improved to reach a more fairly resource allocation. The algorithm is processed in the following way: in the first stage, DEA efficiency score is used for allocating resources uniquely. Then, in the second stage, Shannon's entropy method is used for improving it and finally in the third stage, a linear programming model is proposed to allocate resources in a fair manner by combining the results of previous stages and Gini coefficient method.

## DEA2016-P082

### **Load Balancing and Resource Allocation Management with Data Envelopment Analysis Methods in Cloud Computing Environment**

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Cloud computing allows business customers to scale up and down their resource usage based on needs. Cloud computing entrusts services with a user's data, software and computation over a network. The remote accessibility enables us to access the cloud services from anywhere at any time. To gain the maximum degree of the mentioned benefits, the services offered in terms of resources should be allocated optimally to the applications running in the cloud. Cloud computing is one of the latest and upcoming paradigm that offers huge benefits such as reduced time to market, unlimited computing power and flexible computing capabilities. In this paper we proposed a new load balancing mechanism to resource management and distribution of workload to all nodes in the system to achieve a higher resource utilization and user satisfaction. We use the Data Envelopment Analysis methods as a new approach for load balancing and resource management technique. Simulation results show that our proposed method improved cost of servicing, system overhead, reliability and maximum completion time.

## DEA2016-P083

### **A Generalized Revenue Efficiency Measurement with Fuzzy Data**

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The conventional revenue efficiency models are capable of measuring revenue efficiency with exact data. In the event that, in real world, the exact amount of data is not always exist and most of them are fuzzy nature. To investigate the revenue efficiency with fuzzy data, researchers proposed fuzzy revenue efficiency models. However, these models are limited to a special type of fuzzy data and cannot evaluate fuzzy sample decision making units. The proposed model, in this paper, overcomes the limitations of the previous models and is capable of evaluating the revenue efficiency measure of a fuzzy sample decision making unit. Then, five methods are provided for evaluating the revenue efficiency score of a fuzzy sample decision making unit and these methods not only improve the previous methods, but also for the first time, the concept of vector has been employed to measure revenue efficiency.

## DEA2016-P085

### **The Efficiency of Cooperative Financial Institutions in South Africa: An Empirical study using DEA Approach**

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This study is set out to empirically investigate the levels of efficiency of Cooperative Financial Institutions (CFIs) in South Africa covering the period 2008 to 2014. The current failure rate of CFIs and the drop of membership call for an urgent systematic evaluation of CFIs performance to be able to make evidence-based policies and management decisions. This is despite South African government efforts to promote CFIs as an alternative intervention to improve access to financial services. The ultimate objective of the study is to build a more efficient CFI sector that continues to improve access to finance to the economically poor households. The study will make use of both theoretical and empirical efficiency models to measure and understand the industry's efficiency. The study will specifically use data envelopment analysis (DEA) approach to evaluate efficiency. The Panel Data Analysis will be employed to analyse the performance drivers among CFIs. The Cooperative Banks Development Agency of South Africa will be used as a source of empirical data in form of financial statements of CFIs for the period under the study. The empirical findings of the study will assist in building a more efficient industry through evidence-based recommendations. In addition the findings will make a contribution to the growing microfinance/credit union performance measurement empirical literature.

## DEA2016-P086

### **Financial inclusion in Colombia: evolution and relative efficiency**

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Financial inclusion is related to the level of access a given population has to the different regulated financial products and their effective use by the same. Essentially, access to financial services is a necessary but not sufficient to achieve financial inclusion, it is required so ensure effective use thereof. However, insufficient financial inclusion by groups of a society can delay development and economic growth and contribute to social inequality. That is why the study of financial inclusion is important for a country like Colombia, which seeks to accelerate processes of equal opportunities within their society. This research analyzes the situation and development of financial inclusion of this country from the point of view of relative efficiency, taking into account the main points of access to the regulated financial system such as offices, banking correspondents, data phones and ATMs. This is taken as a starting point using the results of relative efficiency of financial inclusion of 2013 and examining its evolution to the results of 2014.

## DEA2016-P090

### **Allocation of personnel and equipment for the Keelung Harbor Terminal - an application of multi-activity centralized data envelopment analysis**

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In this study, the Multi-Activity Centralized Data Envelopment Analysis (MCDEA) is proposed for reallocating the personnel and equipment resources of the Keelung Harbor Terminal, based on the maximum overall cargo handling capacity of the terminal. Given the difficulty of greatly restructuring the operation of a public organization in the short run, which may draw backlash particularly with a large-scale adjustment, this study sets the scenarios on small, medium, and large scale resources adjustments, for the Keelung Harbor Authority to take reference in making its progressive adjustment programs. The results will help the Authority effectively schedule their reallocation of the personnel and equipment resources. The empirical results show that the proposed scenarios can be practically applied to the personnel and equipment resource allocation of Keelung Harbor, and therefore provide valuable reference in decision making by the harbor authority.

## DEA2016-P093

### **A Comparative Analysis of Technical Efficiency between Chinese and Indian Commercial Banks: SFA Approach**

**Huajie Zhang**

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**Nan Zhu**

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In this paper, we make comparative analysis of technical efficiency between Chinese and Indian commercial banks by using stochastic frontier analysis (SFA) approach. The results are also compared with the results obtained by using a non-parameter approach: data envelopment analysis (DEA).

## DEA2016-P097

### **An allocation Malmquist index with an application in the China agricultural industry**

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This paper describes a model of an allocation Malmquist index, which is corresponding to the traditional non-parametric Malmquist index. An application in corporate management of the China agricultural industry with the panel data set of 72 companies during the period 2009-2013 is discussed.

## DEA2016-P100

### **On Eco-efficiency of Provincial Regions of China: DEA approach**

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By using data envelopment analysis (DEA) models, we make analysis on Eco-efficiency of China's 31 provinces, municipalities and autonomous regions. We discuss and provide strategic paths for green industrial development of the regions in terms of economic and ecology efficiencies of DEA models.

## DEA2016-P101

### **Efficiency of the banking industry in Romania and Bulgaria: Application of the Dynamic DEA**

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The aim of the paper is to estimate the efficiency of the banking sector in Romania and Bulgaria. The Dynamic Data Envelopment Analysis is employed for estimation of efficiency of the commercial banks. We use the input-oriented model. Next, we calculate the scale efficiency of the commercial banks. For determination of inputs and outputs we adopt the intermediation approach and we assume that the main aim of the bank is to collect deposits and transform them into loans. Next, we estimate the determinants that influenced banking efficiency. We apply the panel data analysis and as the determinants we use banks-specific factors, industry-specific factors and macroeconomic factors. The structure of the paper is following. First, the empirical analysis is presented and the methodology and data is described. Next part is empirical analysis and last we discuss the results and findings.

## DEA2016-P104

### **Comparison of operating efficiency of government operated and private airports in India**

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Till the introduction of the liberalization process in the 1990s Indian policy makers were guided by the philosophy of self-reliance and public sector dominance. The air transport and especially airports management sector was also no exception. Following the reforms of 1990s, in 2003 the first decision of handing over of terminals of the major airports of Delhi and Mumbai to the private operators was taken. The paper analyzes 72 Indian domestic and international airports operated and owned both by government and private players in the time frame from 2006 to 2009. For this Data Envelopment Analysis (DEA) has been used to develop a multivariable measure of efficiency of the privatized and non-privatized airports of India. A comparison is made in the paper between the private and government operated airports on the basis of the multiple outputs of flights per day, passengers per day, cargo handled per day and revenue generated of the

airports and the apron capacity, number of runways, terminal area and expenditure of the airports as inputs. The efficiency values obtained from the DEA models of CCR and BCC shows that privatization in the India has worked positively showing greater operational efficiency than those operated by government.

## DEA2016-P105

### **Discriminating power of DEA and selecting the number of inputs, outputs versus number of DMUs: A simulation study**

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Ever since the birth of Data Envelopment Analysis (DEA), the question of how to choose the number of inputs, outputs versus the number of DMUs has been one of the focal research points. Conceptually, it is well known that if too many inputs and outputs or too few DMUs are used, the discriminating power of DEA models will be much weakened. Many guidelines for selecting the number of inputs, outputs and DMUs to improve the discriminating power of DEA are thus proposed based on empirical studies, but without any quantitative analysis. In this study, we propose a new guideline to select the number of inputs, outputs and DMUs. First, we define a new measure to evaluate the discriminating power of DEA models (CCR and BCC model). This measure does not only evaluate the discrimination between efficient DMUs but also evaluates the discrimination between inefficient DMUs with the same ranks. Then, by employing a simulation study, we show how the discriminating power of DEA is related to various combinations of the number of inputs, outputs and DMUs. Finally, based on the proposed approach, we quantitatively provide a guideline how to choose the number inputs, outputs and DMUs.

## DEA2016-P107

### **Electricity Efficiency Change in China and its Economic Explanation**

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Electricity as an important secondary energy form is widely used in our daily life. Electricity consumption process is also strongly correlated with fossil fuel combustion and massive greenhouse emission. This article uses the DDF-SBM method to estimate the electricity consumption efficiency in China. We study both the static electricity efficiency and dynamic productivity index in China's regional and provincial level. The results



indicate that the overall trend of China's total factor electricity efficiency may strongly correlate with the national policy and China's economic transition process. Salient discrepancies could be found in different regions and provinces in China. Furthermore, both the national and provincial industrial structures are important factors to explain the total factor electricity efficiency change in China. From the analysis, several policies and mechanisms could be implemented by the government in promoting electricity efficiency in the years ahead.

## DEA2016-P108

### **A Data-driven Prediction Approach based on Data Envelopment Analysis: An Application to NBA Teams' Performance**

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Data envelopment analysis (DEA) is well known as an ex-post evaluation approach. This paper first proposes a data-driven approach based on DEA, which is an ex ante prediction approach, and applies the proposed approach to predict performance of NBA teams. The numerical example shows that the proposed approach can give a quite precise prediction of NBA teams' performance.

## DEA2016-P109

### **What Determines the Efficiency of Public Secondary Schools in Pakistan? A case study of Multan district**

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The purpose of this paper is to estimate the efficiency of higher secondary schools in Pakistan. The evaluation of performance of education institutions is considered important for the effective allocation of resources. Developing countries like Pakistan have started putting greater emphasis on education and during last decades governmental spending on education has increased substantially. Unfortunately, there has been little work to evaluate the performance of education sector in developing countries. Similarly, this study is first study where the performance of high secondary schools is estimated in Pakistan. This study measures the efficiency of public secondary schools in Multan district which is considered to be one of the most backward areas in Punjab province of Pakistan. The study estimates the efficiency of 134 public secondary schools of by employing "Data Envelopment Analysis". The result of students and grades are the output measures while

the average teaching experience, professional qualification, total teaching and non-teaching staff etc. are the major inputs. We have estimated the technical as well as the scale efficiency of the schools.

## DEA2016-P110

### Performance Efficiency of Sustainable Practices in French Wine Regions Using Data Envelopment Analysis

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The primary objective of this research is to assess French wine regions based on an environmental perspective to help in implementing sustainability in wine industry. In this study, we aim to evaluate the performance efficiency of the major French wine regions in terms of carbon footprint practices using data envelopment analysis. To accomplish this, we will use an output oriented version of the weighted additive model introduced by Lovell and Pastor (1995). This methodology is characterized by accounting for slacks as a source of technical inefficiency contrary to other approaches that neglect slacks thus leading to an overestimation of the allocative inefficiency. After calculating the efficiency for each wine region, we will introduce the carbon footprint environmental factor to test how performance efficiency is affected. We are mainly interested in three sources of carbon emission which are the soil, transportation, and packaging. With the results of this study we expect to provide winemakers and regional authorities with the relevant information regarding performance efficiency of sustainable practices existing in the French wine sector.

## DEA2016-P112

### An Out-of-Sample Evaluation Framework for DEA

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Nowadays, Data Envelopment Analysis (DEA) is a well-established non-parametric, frontier-based methodology for performance evaluation and benchmarking. DEA has witnessed a widespread use in many application areas since the publication of the seminal paper by Charnes, Cooper and Rhodes in 1978.

However, so far DEA lacks an out-of-sample evaluation framework, and applications in risk modelling and analysis require such a setup to gain popularity amongst practitioners in this area. In this paper, we fill this gap by proposing a framework for the out-of-sample evaluation of decision making units. We illustrate the use of the proposed framework in risk assessment and bankruptcy prediction of companies listed on the London Stock Exchange.

## DEA2016-P113

### **A DEA-based Framework for Assessing Banks Risk Profiles**

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The banking sector plays a crucial socio-economic role at the regional, national and international levels. Banks are at the heart of financial systems in that they act as financial intermediaries. In addition, they play an important role in money supply and the efficient allocation of financial resources in an economy. Because of the crucial importance of banking systems to the economy and the financial risks they face, banks' performance and risk profiles are continuously monitored by a range of stakeholders. In this paper, we propose a DEA-based framework for assessing the risk profile of banks. The performance of the proposed modelling and analysis framework is assessed using a sample of UK banks.

## DEA2016-P114

### **An approach for improving the frontier in the DEA models**

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Every mathematical model is just an approximation of the real-life processes and phenomena. So, inadequate results may appear in the DEA models. In our previous papers [1,2] we discovered the reasons of such results. Moreover we introduced the notion of terminal units. We also established relationships between different sets of units that may cause inadequacies in the DEA models (terminal units, different sets of anchor units, exterior units). It was also proved that only terminal units form necessary and sufficient set of units that were introduced in the DEA literature in order to smooth the efficient frontier. In this paper, the approach is developed for improving the frontier in the DEA models, which is based on using the set of terminal units as a starting point. In the design of the approach we assume as basis that the main properties of the DEA models

have to be preserved. Our theoretical results are verified by computational experiments using real-life data sets and also illustrated by graphical examples. The authors were supported by the Russian Foundation for Basic Research (project no. 14-07-00472).

## DEA2016-P117

### Visualizing DEA efficiency-configurations

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The number of Decision Making Units (DMUs) varies widely among all the various Data Envelopment Analysis (DEA) applications. And with increasing number of DMUs, it becomes more and more difficult to prepare and represent the DEA results; most seriously: in case of multiple optimal solutions. Here it is well-known that the composition of benchmarks in the so-called envelopment-form and the weighting-scheme in the multiplier-form can be non-unique, although the efficiency-score remains the same for the DMU under consideration. This immediately leads us to two questions: what can be learned from these different compositions and how can we visually explore it? In order to treat both aspects, this contribution focuses on the above stated weighting-scheme – we call it an efficiency-configuration. From this perspective the decomposed objective function value helps us to localize the DMU's activity specialization. A technique called Multidimensional Scaling then allows for a visual identification of clusters among all DMUs with respect to their specialization – more precisely, their efficiency-configuration. But such a clustering should be studied in the presence of multiple optimal solutions. This is topic of the present contribution. Finally, after developing the respective theoretical concepts, a real-world application will be examined and discussed.

## DEA2016-P120

### Application of DEA in Evaluating Relative Efficiency of Iranian Flights Generating Income

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The policies and planning of Iran airline industry is derived from five-year national development plans that focus on continuous improvement of the quantity and quality characteristics of the business environment. The purpose of this study is to evaluate efficiency of Iranian Airlines using DEA method based on the latest statistics provided by Iran Civil Aviation Organization in the first three years of the fifth development plan

(2011, 2012, and 2013). The article tries to evaluate efficiency of 16 airlines using two outputs, Revenue Passenger Kilometer (RPK) and Revenue Ton Kilometer (RTK), as well as two inputs, Available Seat Kilometer (ASK) and Available Ton Kilometer (ATK). This paper measure the efficiency of airlines in domestic and international flights using constant returns to scale (CRS) and variable returns to scale (VRS) both on input oriented approach. The results show the average of relative efficiency of airlines in three years under CRS is 0.905 in which 12% of airlines are efficient. Moreover, the average of efficiency under VRS is 0.955 and 58% of airlines are efficient. Besides the scale efficiency, the industry serves about 6% less than the full capacity that represents high demand volume and low supply in Iran airline industry. This finding suggests that the industry can be considered as valuable opportunity for foreign investment in Middle East after removal economic sanctions of Iran. Another notable finding is the difference in the scale efficiency of three airlines compared to others: Iran air as the only state- owned airline, Mahan Air as the largest airline and HESA as the weakest fleet airline.

## DEA2016-P122

### Technical efficiency of chili farms in Thailand under Good Agricultural Practice System

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The main purpose of this study is to measure and investigate factors affecting technical inefficiency of chili farms in Thailand. The data envelopment analysis (DEA) approach and farm-level cross-sectional survey data of chili farms in the Northeastern Region in Thailand are used to estimate technical efficiency scores. The empirical results suggest two important findings. First, the overall technical, pure technical and scale efficiency scores of some farms were considerably low. Second, there is confirmation that farm size, chili production systems and farm management differences have influenced the overall technical and scale inefficiencies of chili farms in Thailand.

## DEA2016-P127

### Solving multi-objective 0-1 linear programming by using data envelopment analysis method in the presence of negative data

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This paper proposes a method to find Pareto optimal solutions for multi-objective binary linear programming (MOBLP) problems by using data envelopment analysis (DEA) technique. This method transfers the MOBLP

problem into the DEA framework and simultaneously states DEA model as a bi-objective Problem. To this end, for each feasible solution of 0-1 MOLP problem, a decision making unit (DMU) is constructed in which outputs and inputs vectors for given DMU are respectively the values of objective functions and constraints in the feasible point. To deal with negative values of inputs and outputs we adopt an existing DEA model that is adequate for this case. DEA technique is able to find the set of Pareto solutions for the constructed DMUs. The proposed method is computationally efficient against previous methods consisting of an algorithm or several algorithms by adding constrains in each iteration. Several computational examples illustrate the proposed approach with an impressive computational time-saving.

## DEA2016-P128

### **Evaluating Health Care Efficiency of Turkish Cities by Data Envelopment Analysis**

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Turkey has made intense efforts to achieve accurate and sustainable health care systems since the implementation of health transformation program. The objective of this study is to evaluate the health care efficiency of 81 Turkish cities for the year 2011 by using Data Envelopment Analysis (DEA) technique after the implementation of health transformation program. Efficient and inefficient units were determined by two DEA models. Furthermore, in order to classify the cities for which the assessment values equal to 1, the super-efficiency model is applied for further sorting. The evaluation of the scale efficiency results show that 74% of the cities (n=60) have been found to be inefficient whereas 26% of the cities (n=21) have been found to be efficient in Turkey's health care sector.

## DEA2016-P130

### **Using the Spatial Econometric Approach to Analyze the Impacts of Technical efficiency from CCDEA Model at the Provincial Level in VietNam**

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This paper employs the spatial econometric approach to analyze technical efficiency convergence from constrained programming model (CCDEA) of the industrial sector among sixty provinces in Vietnam in the period 1998-2011. It is shown that the assumption of the independence among spatial units (provinces in this case) is unrealistic, being in contrast to the evidence of the data reflecting the spatial interaction and the existence of spatial lag and errors. Therefore, neglecting the spatial nature of data can lead to a

misspecification of the model. We decompose the sample data into the sub- periods for the analysis. We employ the maximum likelihood procedure to estimate the spatial panel model, spatial lag panel model and spatial error panel model. The estimation results allow us to recognize that technical efficiency estimated from CCDEA model exists spatial convergence.

## DEA2016-P132

### **Chinese regional energy-economy-environment efficiency analysis based on the 3E DEA model**

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Data envelopment analysis (DEA) has been widely used in measuring the performance of energy and environment in recent years. People often ignored the undesirable outputs and did not separate the inputs into energy inputs and non-energy inputs. Even if people take these issues into consideration, they imposed the weak disposability on all the undesirable outputs. But it is often in contradiction with the technical features of the undesirable outputs. Also there does not exist a DEA model which considers the energy-economy-environment efficiency. This paper presents a new DEA model to evaluate the energy-economy-environment efficiency while imposing the proper disposability on the undesirable outputs depending on the technical features (hereafter referred to as the 3E DEA model) and constructs an index to show the efficiency. Finally, it is used to evaluate the 29 administrative regions of different areas from 2010 to 2012 in China. The Malmquist index is constructed based on the 3E DEA model to appraise the development trend.

## DEA2016-P136

### **Comparison between Conventional Banking and Islamic Banking in terms of X-Efficiency using Data Envelopment Analysis and Malmquist Productivity Index Analysis**

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In this research work, attempts have been made to compare performance of Conventional banking and Islamic banking in terms of x-efficiency and various efficiencies and productivity changes. Twenty three banks from Conventional banking system and seven banks from Islamic banking system have been selected systematically based on the principle that the selected banks cover at least eighty percent of their respective total asset. The study period of the analysis is from 2009 to 2014. The data are collected from various secondary sources including respective banks' annual reports of selected banks. Comparison of two banking system in terms of efficiency has been made using Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI). The overall mean value of Technical efficiencies is better for Islamic banks than those of Conventional banks. However Scale efficiencies are opposite scenario during the year from 2009 to 2012.

Technical efficiency change, Pure efficiency change, Scale efficiency change and Total factor productivity change of Conventional banks and Islamic banks calculated using Malmquist Productivity Index have revealed ups and downs in their performance. However, some sorts of mixed pictures for more desirable changes have been observed in case of Islamic Banks. On the whole, it can be concluded that Islamic banks being new in the banking business have been being considered to be more efficient with their new ideological principles relative to their Conventional counterparts despite experiencing less scale efficiency in the beginning of the study period. However, to increase banking performance, good banking management and allocation of inputs should be important for the banking system especially for conventional ones.

## DEA2016-P137

### **Efficiency Analysis of Group Banks of Bangladesh in Managing Non-Performing Loans (NPL) using Data Envelopment Analysis (DEA)**

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This paper analyses the efficiency of the group banks in Bangladesh in dealing Non-Performing Loans (NPL). We apply non-parametric technique, the Data Envelopment Analysis (DEA) utilizing the banks' annual data from 2008 to 2014. The input bank-specific variables are total loans (un-classified), total deposits, total assets and the output variables are classified loans, categorized as Sub-standard (SS), Doubtful (DF) and Bad & Loss (B/L) circulated by Bangladesh Bank's principle. This study has explored technical efficiencies of group banks showing technical inefficiencies 0.489 (TIE-crs) and 0.838 (TIE-vrs) for State owned banks (SOBs), 0.271 (TIE-crs) and 0.366 (TIE-vrs) for Private Commercial Banks (PCBs) and 0.210 (TIE-crs) and 0.246 (TIE-vrs) for Islamic Banks (IBs) respectively. The results show that IBs' performance is better than PCBs regarding NPL. Moreover, IBs' and PCBs' performances are also better compared to SOBs' performance. The study will have important implications for Bangladesh Bank's regulation and supervision as well as Government policy development to reduce the NPLs in banking sector which is going through an alarming condition nowadays in Bangladesh.

## DEA2016-P139

### **Nonparametric Measures of Efficiency in the Presence of Undesirable Outputs: An Inter-country Analysis of GDP and Pollution**

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In empirical research on productivity measurement adjusted for pollution, the good and the bad outcomes are treated as joint-products of the underlying production process. In the present paper, following Murty,



Russell, and Lebekoff (MRL), we adopt the by-production interpretation of bad output generation. Also, we conceptualize the good output as technologically separable from the bad output. However, unlike MRL we set up an integrated DEA optimization problem to measure the efficiency of a firm that produces a bad output alongside the good output. We use country level data for an unbalanced panel of 64 countries over the years 1986 through 2011 where per capita GDP is the good and per capita CO2 emission is the bad output. We utilize our DEA results to compute opportunity costs of reduction in CO2 emission in required dollar amounts of reduction in per capita GDP for the individual countries in selected years.

## DEA2016-P140

### Fundamental Analysis and Firm Efficiency

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Fundamental analysis is a technique that attempts to determine the value of corporate securities by examining key value-drivers such as earnings, growth, and competitive position. It uses information in financial statements to gain insights about a company's future performance. However, a signal used in fundamental analysis may have different implications for future earnings under different circumstances (Lev & Thiagarajan [1993]). In this study, we consider, as a new signal for fundamental analysis, a relative measure of firm efficiency using data envelopment analysis (DEA) and investigate whether it has incremental explanatory power for estimating stock returns and future earnings. We also distinguish between sales-increasing and sales-decreasing periods of a firm as two different situations for evaluating firm performance. We investigate how the implications of signals used in fundamental analysis differ between sales-increasing and sales-decreasing periods. We find that an increase in firm efficiency is a favorable signal for one-year-ahead earnings change and annual excess stock return when sales increase, but an unfavorable signal for one-year-ahead earnings change when sales decrease. We also find that some signals, based on SG&A costs, inventory, accounts receivable, capital expenditure, and gross margin, are either only informative or are more pronounced in one of the two situations - either sales-increasing or sales-decreasing periods.

## DEA2016-P141

### Different Estimation Effects between Inverse CCR and BCC model

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This paper analyzes the different output estimation effects between inverse CCR model (In-CCR) and inverse BCC model (In-BCC) based on efficiency decomposition from a long-term input adjustment view, considering global technical efficiency (TE), local pure technical efficiency (PTE), and scale efficiency (SE), which provides the basis for the choice of different inverse DEA models. Firstly, one single input and single output case is discussed to verify the output estimation and the efficiency value. Then, the theoretical results for multiple input and output case have been demonstrated. In practical, PTE indicates the current production technology level of DMUs, the adjustments of which requires a long-term program. SE represents the current production scale of DMUs, which can carry out a reform through a short-term plan. Both In-CCR and In-BCC want to improve the SE of DMUs, while In-CCR reduces the PTE to improve the SE of DMUs, keeping TE unchanged, and In-BCC only need to increase SE of DMUs by keeping PTE constant. Finally, we get the conclusion that In-BCC has more reasonable estimation effect than In-CCR, considering the practical operability.

## DEA2016-P143

### **How ICT is affecting the efficiency of healthcare system in Tunisia and Oman: A dynamic assessment using Malmquist Index**

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The public healthcare system is providing a crucial service to the citizens of any country. Though governments are continuously working on improving this system by investing large shares of budget, it remains largely criticized for the quality of service provided and for its technical efficiency in transforming resources into outputs. ICT is impacting positively and is muting the healthcare systems around the world. This impact certainly varies among countries due to many factors. This study analyses the impact of ICT on the healthcare system in two countries, namely the Sultanate of Oman and Tunisia. The Sultanate of Oman, a wealthy country in the Gulf region, is engaged in the implementation of an e-health program aiming to improve the services provided by the healthcare system in the Sultanate. Tunisia, in a transitional political period, was engaged in improving its healthcare system through limited implementation of ICT solutions. The objective is to analyze over time the two experience and provide guidance for a better efficiency. The Malmquist Index will be used for the dynamic analysis of the two systems.

## DEA2016-P149

## **Bank Efficiency of Domestic and Foreign Banks in China**

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In this research paper, we analyze bank efficiency of domestic and foreign bank branches in China using a non-parametric data envelopment analysis (DEA) approach as well as two accounting based measures for efficiency, the net interest margin and the cost to income ratio. A total of 667 annual efficiency scores of commercial banks operating in China from 2007 to 2014 are analyzed. Inputs for the DEA analysis include personnel expense, fixed assets, and short term funding; outputs comprise loans and other earning incomes. The results of DEA based efficiency show that foreign banks are more efficient when converting inputs to outputs compared to domestic banks except for the year 2009; however, domestic banks are throughout more efficient with respect to net interest margin and cost to income ratio. The findings reflect the fact that foreign bank branches in China still have limited channels to fund themselves on the local capital market and therefore have higher financing cost, demonstrated by the lower net interest margin.

## **DEA2016-P154**

### **Production Efficiency in Chinese Agriculture: An Assessment of the Post Economic Reforms Years**

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Since the Chinese government initiated a series of reforms of the economic system before 1980s China has experienced impressive growth in agricultural production. Agriculture is one of the most important economic sector in China, employing over 300 million farmers. It is important to look at the technical efficiency change and see whether the China's achievement of an economic miracle since the economic reforms has resulted in an increase in the technical efficiency. After providing a brief overview of the nature and trend of economic reforms, a non-parametric methodology of Data Envelopment Analysis (DEA) for measuring technical efficiency and its change is introduced. To estimate the overall technical efficiency and its components, we obtain Pareto-Koopmans measures of technical efficiency of 119 counties in Shanxi province of China during the period from 1981 to 2010 in a multi-output and multi-input production framework. We disaggregate overall efficiency into output-oriented and input-oriented efficiencies. Next we identify the contribution of

the individual outputs and inputs to the measured level of overall technical efficiency. Also we examine the performance of modern agricultural inputs and compare them with the traditional inputs.

## DEA2016-P156

### **Performance Assessment of Public Hospitals in Saint Petersburg: Application of SFA and DEA Models with Undesirable Output**

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The purpose of the study is to evaluate the performance of Saint-Petersburg city public hospitals with regard to the use of resources provided by the Obligatory Medical Insurance (OMI) system. The public hospitals' costs of medical services to the city population are compensated by medical insurance companies (through OMI Fund of St. Petersburg) in part related to material costs (they cover expenditures on medical supplies, food, bedding and linens except expensive high-tech equipment and capital repairs) and labor costs (salaries paid to the medical staff). The hospitals' performance is assessed against two outputs: a) the total number of treated inpatients and outpatients; b) the total volume of hospital's invoices refused for payment by the medical insurance companies or the number of cases when the costs of patient's treatment were rejected for payment by the medical insurance companies. The study compares the results of evaluations conducted in single and multiple output settings. To assess the performance of 47 St. Petersburg public hospitals in 2013 and 2014 the DEA (BCC-Output) and SFA models were applied. The normalization of the variable of refused payments was used in BCC model to account for undesirable output. The proposed normalization was compared to other approaches used for accommodating the undesirable outputs. The findings of the study demonstrate that single output setting gives similar efficiency ranking of the hospitals comparing DEA and SFA results. Accounting for undesirable output essentially changes the hospitals efficiency ranking. The BCC models with undesirable output variable measured in total volume of refused for payments and number of rejections to pay, also demonstrate meaningful differences in efficiency scores. The efficiency scores are lower in the latter case.

## DEA2016-P157

### **Labor Cost Efficiency of Bank Branches in India**

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Commercial banking is based on the operation of a network of bank branches. Branches facilitate the financial intermediation process by mobilizing deposits that generate funds to be invested by the bank. They are involved in all the crucial steps of modern banking like cost management, recovery management, technology, risk management, and governance. It is the branch where the use of resources, tolerance of waste and slothfulness get manifested which finally contributes to low efficiency and productivity of banks. In this paper, using a unique DEA application, we focus mainly on measuring and analyzing labor-cost inefficiency of bank branches in India, one of the fastest growing countries in the world whose financing system is traditionally bank based. This study is designed to measure the branch-level labor-cost inefficiency of a single bank across India's four biggest metropolitan cities, viz., Mumbai, Delhi, Kolkata, and Chennai which are identified by the uniqueness of people, work culture, socio-economic progress and attitude. We introduce the concept of intra and inter efficiency which control for the effect of the organizational differences across regions. Empirical results show that a substantial portion of labor cost stems from inefficiency. Cost reduction is evident for all classes of employees in every region. Even within any one region there exists considerable labor-cost inefficiency and the inefficient branches can accomplish substantial cost saving in their personnel expenditure by following other branches within the same city as their role models. Cost saving is feasible even when operating within the constraints imposed by the regional work culture. This is the target that the regional management could set from the branch and make the branch management accountable if it fails to meet this objective.

## DEA2016-P159

### **Efficiency of SMEs Financed by Conventional and Non-conventional Banks: Bangladesh Perspective**

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SMEs in Bangladesh are given priority in lending and playing crucial role in contribution to the country's GDP. However, a field survey was conducted in 2012 to find out the impact of huge expansion of loans. Results of that survey show sized and/or manufacturing enterprises contribute the most in productivity and employment generation. However, while considering efficiencies of SMEs with a distinction between financing from conventional or non-conventional bank through Data Envelopment Analysis (output oriented model) with that survey data of 283 enterprises for the period 2009-2011 and consideration of one output variable (sales) and four input variables (capital, loans, expenditure and manpower), we found that the same technical efficiencies (constant return to scale) of SMEs between two types of bank financing—conventional (0.241) and non-conventional (0.243). However, a slight difference of efficiencies of SMEs financed under two

types of financing is observed while considering the size, sector and region where they are producing. The slight differences come from the concessional lending, access to finance and monitoring and supervision.

## DEA2016-P160

### **Detecting the QRS complex based on DEA and cross-efficiency evaluation**

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In this paper we employ data envelopment analysis (DEA) models in identification of QRS peaks from a ECG signal which could be very noisy. The accuracy in detection of electrocardiographic (ECG) heartbeats greatly influence the outcome of following diagnose process, and previous methods always fail to discriminate the real abnormal signals from the noisy signals. DEA methods as a classical evaluation and ranking method are considered in analyzing clinical ECG signals. Five index are included such as height of peak (H), width of peak (W), height to weight value (H/W), slope of peak point (Slope), and RR interval. According the score result evaluated by DEA, all the R peaks are of high score, and most of noisy peaks are of low score. Cross-efficiency evaluation is used to improve the outcome by DEA models. A merit of DEA method for ECG analysis is that the derived weights for QRS complex can be used vastly in long term ECG identification, and related DEA models such as cone DEA, common weight models, and cross evaluation DEA models can be well used to improve the heartbeats classification.

## DEA2016-P161

### **Top Management Team Compensation, Strategic Positioning, and Firms' Competitive Effectiveness**

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This study investigates how the compensation structure of the top management team (TMT) affects the firm's competitive effectiveness under different strategies. We delineate the TMT compensation structure along two dimensions - the CEO pay slice and pay dispersion among the CEO's top team. We adopt an innovative measure of firm competitive effectiveness that uses Data Envelopment Analysis (DEA) to determine a firm's relative efficiency in converting firm resources into revenues compared to the industry leader (Demerjian et al., 2012). Using Miles and Snow's (1978, 2003) strategic typology to classify firms, we find that the association between CEO pay slice and competitive effectiveness is more positive for firms following the Prospector strategy than for Analyzers. We also find that higher pay dispersion among the CEO's top team appears to be more harmful for both Prospectors and Defenders than for Analyzers.

## DEA2016-P162

### **Energy Efficiency and Capacity Utilization in Indian Manufacturing: A Tale of Two Industries**

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India has been growing rapidly since the economic and financial liberalization. Given the supply constraints and heavy dependence on imports for energy, achieving efficiency in energy use is of fundamental importance to India's future growth. Studies show that the manufacturing in India is capital intensive for its level of development and factor endowments. The current study uses Data Envelopment Analysis and examines data from the Annual Survey of Industries, India for the period 2004-05 to 2011-12 to understand the relationship between energy efficiency and capacity utilization in two energy intensive industries – (i) paper and paper products and (ii) chemical and chemical products. The results are compared to that for aggregate manufacturing, to provide insights into the specific challenges faced for each industry.

## DEA2016-P163

### **Impact of the Foreign Direct Investment on Chinese Manufacturing Industry – An Empirical Application of Data Envelopment Analysis**

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This paper studies the impact of foreign direct investment (FDI) on the manufacturing industry in China. The output-oriented VRS (variable returns to scale) Data Envelopment Analysis (DEA) model is used to evaluate the technical efficiency of individual firms in the textile industry and beverage industry in China. A second-

stage regression examines to what extent the distribution of efficiency in the exporting-oriented industry and domestic-oriented industry can be explained by the shares of FDI in the capital composition of the firms. The data used in the empirical analysis are drawn from the survey of Chinese manufacturing industry in 2013. We selected 1562 observations for our empirical analysis. The average technical efficiency for textile industry is 62.3%, and the average technical efficiency for beverage industry is 60.7%. The result from second-stage regression shows that FDI has a positive impact on technical efficiency of China's domestic-oriented manufacturing industry, while it might have a negative impact on technical of China's exporting-oriented manufacturing industry. It also reveals that in general, if a firm stays in the manufacturing industry for a longer time, the technical efficiency of the firm tends to be higher.

## DEA2016-P164

### **An application of the hybrid returns-to-scale DEA model with production trade-offs to the efficiency assessment of universities**

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We report on an efficiency assessment of universities in which the number of universities is small compared to the number of inputs and outputs. We demonstrate that the problem arising from the small data sample can be successfully overcome by a thoughtful selection of the DEA model. In this study we use the hybrid returns-to-scale (HRS) model that combines the assumptions of CRS and VRS. This model is further enhanced by the incorporation of production trade-offs. The resulting model is based on the technology that is larger than the conventional VRS technology, and its use provides a tangible improvement to the discrimination on efficiency scores. We discuss in detail the assumptions on which the described methodology is based.

## DEA2016-P165

### **Productivity and New Investment in Information Technology**

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An extensive literature has accumulated around the elusive goals of linking new investment in information technology (IT) to improvements in firm productivity and financial performance. Problems in linking changes in productivity to adoption of new IT stem from difficulties in measuring productivity improvements, failure to consider contextual factors that influence the outcomes of new IT investment, and limited availability of data. Data on IT investment used in productivity studies has primarily been limited to firm-level data on IT spending obtained from annual surveys of large firms. In this study, we address these issues using a unique data source that provides information about new investment in IT at the workplace level. We employ data envelopment analysis (DEA) to measure workplace productivity based on a variety of labor inputs and



operating costs relative to other firms in an industry. This measure has many advantages over previously used measures of productivity based on accounting data. For example, it applies different weights to different types of labor inputs. By calibrating productivity relative to an efficient frontier for the industry, it enables more precise measurement of competitive benefits obtained from new investment than industry-adjusted measures of financial performance. Our analysis considers contextual factors that may influence the productivity and financial benefits obtained from new IT investment, including the strategic orientation of the firm. The data set also provides information about factors that may impede the realization of productivity benefits from new investment in IT. We develop and estimate a structural equation model (SEM) that relates financial performance to changes in workplace productivity resulting from new investment in IT and other innovation activities. We model strategy and other factors as moderating variables that influence the relations between financial performance, productivity and IT investment.

## DEA2016-P168

### **Estimation of the Opportunity Cost of Pollution Abatement: Interstate Analysis of US Agriculture**

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Interest in reducing undesirable by-products that unavoidably arise out of the production (and consumption) of desirable marketed goods and services has been growing fast over the recent decades. Environmental pollution is one such bad output from the use of chemical fertilizers and pesticides in agricultural production. Pollution abatement requires either lowering the use of such chemicals detrimental to the environment or diversion of other resources from production of the desired outputs (crops and livestock) towards abatement activities (such as treatment of toxic water before discharging into rivers). Serious concerns have emerged whether this reallocation of inputs to pollution abatement would become a significant drain on the economic health of nations, industries, and firms. We apply Data Envelopment Analysis (DEA) to state level data from USDA to determine how much of the desirable output in US agriculture must be foregone for a targeted reduction in pollution.

## DEA2016-P169

### **Nonparametric Estimation of Bank Production and Efficiency in the Presence of Noise**

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Recent developments in the production and efficiency literature allow nonparametric regression estimators with shape constraints. These models bridge the gap between the nonparametric DEA model popular in the microeconomic and operations research literature and the econometric models that allow statistical noise. The newer models relax the assumption of no measurement error in the DEA models without assuming a priori a specific functional form. In this paper we apply these newer models to estimate production and efficiency of Indian Banks.

## DEA2016-P176

### **A New Input-Oriented Plant Capacity Notion: Definition and Empirical Comparison**

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Starting from the existing output-oriented plant capacity measure, this paper proposes a new input-oriented plant capacity measure. Furthermore, we empirically illustrate both input- and output-oriented decompositions of technical efficiency integrating these technical concepts of capacity utilization using a monthly panel of Chilean hydro-electric power plants.

## DEA2016-P177

### **Technical and cost efficiency of Thai sugarcane farmers**

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Thailand's top three economic crops are rubber, rice, and sugarcane. However, prices of these crops have been dropped, especially for rubber and sugarcane. For sugarcane, its price has fallen down due to the excess supply because of extension of world output. Under this situation, improvement of sugarcane farm management should be taken into account. This study aims to estimate technical and cost efficiency of Thai sugarcane farmers by using non-parametric approach. The Data Envelopment Analysis (DEA) on 249 sugarcane farmers in crop year 2014/2015 was carried out. The results show that the average technical and cost efficiency of sugarcane farmers was 0.87 and 0.53. The range of technical efficiency was between 0.40 and 1.00, while the range of cost efficiency of sugarcane farmers was between 0.20 and 1.00. These findings indicate that sugarcane farmers' operation was at low level of both technical and cost efficiency. These were consistent with the results of descriptive analysis of sugarcane chemical fertilizer usage. It was reported that sugarcane farmer overused of chemical fertilizer in the production process. Therefore, farm management

practices such as soil analysis and soil improvement should be considered. Moreover, data in the research indicated that most of them often focus on price instead of net profit.

## DEA2016-P179

### **Relations between DEA and DEA-R based on value efficiency**

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In DEA, in the cases which ratio data is available, DEA-R models can assess decision making units (DMU) easily. In this paper, we present the relations between DEA and DEA-R in constant returns to scale (CRS) technologies. Also, using value efficiency, relations between envelopment DEA and DEA-R models will be studied under two conditions. In the first condition, relations between efficiency measures under will be studied under multiple inputs and one output conditions, and in the second one, we will studied those relations under multiple inputs and outputs conditions, which could be of the ratio kind. In the end, based on units with the highest efficiency, suitable value efficiency models in DEA-R will be suggested.

## DEA2016-P180

### **The evaluation of cross efficiency of DEA two-stage process in the presence of undesirable outputs**

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In this paper, we propose efficiency evaluation models in the presence of undesirable outputs for DEA two stage models based on a directional distance function model. By attention to models have alternative solutions and a large number of units are efficient, we present a new algorithm for cross efficiency calculating. We assume that the outputs are the two types: desirable and undesirable outputs. As well as assuming the inputs are fixed. We show that our algorithm is Appropriate of Point of view Computing. In the following the models are illustrated by numerical example and data bank.

## DEA2016-P181

### **Tolerance Specification of Software Tools for Robust Data Envelopment Analysis.**

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This paper introduces an author written DEA program using Stata software and examines the issue of computation error (tolerance) when dealing with big data. Further it illustrates some mismatched computation results between software tools including R, PIM-DEA, DEAP, and Stata. Finally, it concludes that

users need to know the model specification regarding tolerance and be cautious about the interpretation of computation results.

## DEA2016-P186

### Feature Selection for Classification Using Data Envelopment Analysis

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Feature selection for classification modeling has been attracting increasing attention in many industries particularly in big data processing for its advantages in improving the predictive efficiency, enhancing the intelligibility and reducing the cost of feature acquisition. Different from extant research, we regard feature selection in this paper as an efficiency evaluation process with multiple inputs and outputs and propose a novel feature selection framework based on Data Envelopment Analysis (DEA). We then propose a simple feature selection method based on the framework, where the inputs and outputs make the method supervised learning oriented. Experimental results on twelve UCI datasets indicate that proposed method is effective and outperforms several representative feature selection methods in most cases. The results also show the feasibility of proposed DEA-based feature selection framework.

## DEA2016-P190

### Determinants of Technical Efficiency in Kenyan Manufacturing Sector: A Cross-Sectional Analysis

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The paper sought to examine Kenyan firms' efficiency and its determinants with reference to the manufacturing sector using firm-level data of 2007 from World Bank's Regional Program for Enterprise Development Survey. Results indicate that there exist efficiency asymmetries within the sector ranging from 63.72 to 71.92 per cent on a sub-sector basis and 53.06 to 100 per cent for the entire sector. 62.88 per cent of firms operate under increasing returns to scale, 35.0 and 2.12 per cent operating under decreasing returns to scale and constant returns to scale respectively. Tobit regression results show that firms' age and size enter the inefficiency function positively and significantly. Similarly, firms' age squared and size squared enter negatively and significantly. Firm location also influences efficiency, with firms in Nairobi, Kisumu and Nakuru being comparatively efficient compared to firms in Mombasa. Generally, these results imply that firms operating under increasing returns to scale can further their scope of production by increasing their size with those operating under decreasing returns to scale downsizing. In addition, firm location matters most in the decision to setting up plants in the different regions of the country.

## DEA2016-P191

### **The evaluation of cost efficiency in China's urban water supply utilities**

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In this paper, using data envelopment analysis (DEA) based on deterministic cost frontier function, we construct an index of productivity (cost productivity) to evaluate the cost performance of the urban water supply utilities in China. The change of cost productivity depends on the cost efficiency and cost frontier, and the change of cost frontier involves three factors: the structure of technology, the scale of outputs and the price of inputs. Refer to traditional productivity index decomposition method, the power sources of affecting the cost productivity change are divided into four parts: the change of technical efficiency, allocative efficiency, technology level and the adjustment of factor price. Finally, the impact of market reform on the performance of urban water supply utilities is evaluated by using the econometric regression model in Chinese 208 urban water supply utilities during 1999-2013.

## DEA2016-P192

### **How Serious Overcapacity is in China: Based on a comparative analysis of the static and dynamic methods**

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The enterprise's production process is a multi-stage inputs and outputs and dynamic decision-making process, the traditional efficiency evaluation methods applied only to the initial input and output to calculate efficiency, and ignore the production process during the business activities, which may be errors in the estimation of the degree of excess capacity in China. For this purpose, this paper extends the DSBM model proposed by Tone and Tsutsui (2010), and uses the redundant DSBM model to re-measure the industrial capacity utilization of China's provincial industry. The research shows: (1) there is a significant difference between the traditional DEA method and the dynamic DEA method to measure the capacity utilization. The static method tends to underestimate the capacity utilization, overestimate the excess capacity and the excess volatility of the capacity utilization. Based on the dynamic method, the results show that the average capacity utilization is 60.68%, there is a serious problem of excess capacity, and has the obvious characteristics of pro-cyclicality. (2) based on the dynamic analysis of property rights, industry and scale, the problem of excess capacity exists at all levels. The capacity utilization of state owned enterprises is higher than that of other enterprises, the utilization of heavy industry capacity is lower than light industrial capacity utilization, and the utilization of large scale enterprises is lower than that of small and medium scale enterprises. (3) the eastern region does not exist the problem of excess production capacity, while there are serious overcapacity

problem in the central and western and northeast region. This phenomenon exists in different property, industry and scale, which shows the market level, the degree of openness and efforts to protect property rights and other factors rooted in different areas is the ultimate cause of regional difference of overcapacity.

## DEA2016-P193

### **An Empirical Study on the Efficiency of Urban Water Resource System in China Based on the Analysis of BAM Network DEA Model**

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In this paper, the non-angle and non-radial BAM network DEA model was applied to measure the efficiency of urban water resource system in China during the period of 2003-2012 and explore the causes of their inefficiency. Then, the further study focused on the factors which may impact the efficiency of urban water resource system based on the Truncated Bootstrap Regression Method. The results showed that: during this decade, the urban water system in the eastern regions got the highest complicated efficiency reaching 0.9111 on average; the next were the central regions with an average of 0.7931. The west, however, ranked third with the efficiency of 0.7744. The efficiencies of the production stage and the sewage treatment stage showed the same ranking trend as the complicated efficiency. Adjusting the industrial structure, increasing environmental management efforts, encouraging technological innovation, and making policies according to the regional differences will efficiently promote the balanced development of the region and improve the status of utilization of water resource.

## DEA2016-P194

### **INEFFICIENCY OF VIETNAMESE PANGASIUS FARMING: A DATA ENVELOPMENT ANALYSIS**

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Pangasius has become one of the most important export products of Vietnam. Exports of pangasius were valued around 1.5 billion USD in 2013. Low-value fish such as pangasius has a large range of substitutes and potential supply sources, so pangasius farming in Vietnam needs to produce efficiently in order to compete at world markets. The development of Vietnamese pangasius farming sector also depends on the efficiency with which fish farmers operate. This study aims to investigate the input- and output-specific technical inefficiency of Vietnamese pangasius farming and to identify the impact of the socio-economic characteristics of farmers and farms on technical inefficiency. In this study, technical inefficiencies were computed using a non-radial directional input-output distance function and factors affecting technical inefficiency were identified using a truncated bootstrap regression. Data was gathered through survey among 88 farmers, including small, medium and large scale farms located in both fresh water and salt water intrusion regions in Mekong Delta. Input variables include pond area, capital, costs of feed, labor and others while output variable is revenue. Input technical inefficiency in Vietnamese pangasius farming is relatively low, i.e. 16%, mainly associated with the better use of feed and labor. Output-specific technical inefficiency is 34%, implying that Vietnamese pangasius production performs fairly well. This research provides information that can be used for enhancing the competitiveness of Vietnamese pangasius farming. More specifically, measuring efficiency input-specific and output-specific allows for identifying successful strategies, which minimizing targeted inputs instantaneously maximizing output, for both policy makers and farmers.

## DEA2016-P196

**The low-carbon technology characteristics of China's ferrous metal industry****Ning Zhang**

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**Zhongfei Chen**

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The ferrous metal industry is the largest energy-consuming industrial sector in China. This paper examines the low-carbon production characteristics of this industry during the period 1980-2013. We employ the duality theory of the Weighted Russell Directional Distance Function to propose a general procedure for modeling production characteristics with carbon emissions being considered the undesirable output. Using the Weighted Russell Directional Distance Function model, we measure the carbon-adjusted technical efficiency and environmental regulatory costs for this industry. To investigate policy effects, we test the Porter hypothesis using the Granger causality between regulatory cost and technical efficiency. By using the dual model of Weighted Russell Directional Distance Function, we estimate the carbon shadow pricing and inter-factor substitution possibilities. Results show that the carbon-adjusted technical efficiency and environmental regulation costs of the Chinese ferrous metal industry have significantly increased in recent decades. However, the latter does not significantly cause the improvement of former. The indirect Morishima

elasticities of substitution reflect that the increase of fixed assets will effectively improve the carbon emissions performance of the Chinese ferrous metal industry. Finally, some policy implications are suggested.

## DEA2016-P198

### **Efficiency Among the Sugarcane Farmers of Bhiradichiwadi: A Case Study Using DEA**

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The paper examines the efficiency of sugarcane production from a primary sample of 91 farmers from Bhiradichiwadi, Satara district, Maharashtra using an input oriented DEA model. The paper finds that a mere 19 farmers to be efficient under the VRS or pure technical efficiency.. The slack is largely on account of the expenditure incurred by farmers on fertilizers and manure followed by the expenditure incurred on the purchase of seeds.

## DEA2016-P200

### **On Productive Efficiency and Total Factor Productivity Change of City Commercial Banks of China**

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Having 66 major city commercial banks for example, this paper applies data envelopment analysis (DEA) and the Malmquist index method to measure the productive efficiency and total factor productivity change of city commercial banks of China, based on 2007~2012 panel data. The study shows that in 2007~2012 years the average productive efficiency of city commercial banks of China is at high level ; the impact of the production efficiency affected by pure technical efficiency is greater than that by scale efficiency. From 2007 to 2012, the total factor productivity of city commercial banks of China is improved, the impact of the total factor productivity affected by the production efficiency change is greater than that by the technological progress. The production efficiency due to pure technical efficiency and scale efficiency were improved. The improvement of production efficiency is due to the improvement of pure technical efficiency and scale efficiency.

## DEA2016-P203



## **Improvement in Efficiency Under DEA-based Incentive Regulation of Electric Utilities in Brazil**

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This paper evaluates whether incentive regulation with Data Envelopment Analysis (DEA) benchmarking improves the operational efficiency of electric utilities. Using publicly available data on a panel of electricity distribution firms in Brazil from 2003 to 2012, we find that electricity distribution firms in Brazil have, on average, experienced significant efficiency improvement after the implementation of DEA-based incentive regulation in 2011, even though the DEA benchmarking model used by the Brazilian regulator has several basic deficiencies. We document that the efficiency improvement is pronounced in private sector utilities, but not significant in state-owned utilities. These findings suggest that DEA benchmarking needs to be coupled with the incentives of a privatized industry to promote efficiency improvement.

## **DEA2016-P204**

### **EFFICIENCY GAINS IN CROATIAN ELECTRICITY DISTRIBUTION CENTERS FOLLOWING INDUSTRY STRUCTURE CHANGES**

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Significant changes have occurred in the electric power sector in Croatia in the past decade. HEP (Croatian Power Company) is a state-owned firm with separate subsidiaries responsible for different business activities ranging from power generation, transmission (through a high voltage power grid), distribution (through a medium and low voltage power grid) and the supply of electricity to the end-customer. A major reorganization

during 2006 granted large customers the right to choose their own electricity supplier, thus introducing the pressure of market forces. In this paper we focus on the 21 separate units of the HEP Distribution System Operator (HEP DSO), a subsidiary of HEP, responsible for reliable distribution of electricity in distinct geographic areas in Croatia. They distribute electricity taken from the transmission network to the customers; manage sales, metering, billing and collection for the electricity supplied; and maintain, replace, reconstruct, plan and develop the distribution grid. Each unit faces public and internal management scrutiny with public disclosure of its separate operating performance data. We first estimate the relative efficiency of the 21 electricity distribution centers using a Data Envelopment Analysis (DEA) model with operating costs as the input and total electricity sales, number of customers and network length as the outputs for the period from 2005 to 2013. In the second stage we regress the relative efficiency scores on contextual variables to estimate the impact of the industry structure changes over time, focusing also on parliamentary elections held in 2007 and 2011, considering the fact that HEP DSO remains a part of a state-owned company.

## DEA2016-P205

### ALGORITHMIC APPROACHES TO SENSITIVITY AND STABILITY ANALYSIS IN DEA

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Sensitivity and stability analysis in Data Envelopment Analysis (DEA) for the CCR ratio model of DEA was introduced in the paper 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. (See, the well-known book on DEA Cooper et al. (2006), p. 272.) In this review paper algorithmic approaches to sensitivity and stability analysis in DEA (which are not pursued neither in the mentioned book, nor in the review paper Cooper et al. (2001)) 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.

## DEA2016-P206

### Measuring energy efficiency of wheat production incorporating carbon emission output

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The aim of this study was to analyze efficiency of wheat production in Iran from 2000 to 2010 by applying output-oriented data envelopment analysis (DEA) considering undesirable emission output. Labor, seed, machinery and fertilizer energies were input factors and wheat yield and CO<sub>2</sub> emission were outputs. Results showed that Tehran province had the highest efficiency (99.9%) followed by Khorasan, Bushehr and Ardebil provinces, and Kordestan, Hamedan, Zanjan and Ilam showed the lowest efficiency. Efficient DMUs varied from 4 in 2001 to 11 in 2010. The average efficiency reached from 55.8% in 2002 to 94.2% in 2010. According to optimization results, 28% reduction in CO<sub>2</sub> emission is possible mainly by decrease use of fertilizers.