WELCOME BY EMMANUEL THANASSOULIS, CHAIR OF THE ORGANISING COMMITTEE

4th International Symposium on DEA, 2004

On behalf of the Organising Committee I am delighted to welcome you all to the 4th International Symposium on DEA, at Aston University. The University is located at the heart of the city of Birmingham, itself located at the centre of England.

Birmingham, with a population of one million inhabitants, is a vibrant multi-ethnic city and the centre of a wider region of some 7 million people. Long since known as the home of manufacturing and of the automotive industry in the UK, the city has in recent times added education, finance, transport and many other services to its booming economy. While in the city you will have the opportunity to sample both its historical and its modern attractions, many of which are within walking distance of the conference venue.

The Committee is very pleased about both the number and the quality of the papers submitted. Delegates will have the choice between five parallel streams and poster presentations. As conference organisers, we are especially happy to support those new to research or to research in the efficiency and productivity area. The Conference has been designed with special attention to such researchers and features not only a Special Issue of the *Journal of Productivity Analysis* but also sessions with special advice for conducting and publishing research in this area.

Once again on behalf of the Organising Committee I wish you all a successful and enjoyable conference.

ORGANISING COMMITTEE:

Ali Emrouznejad	Coventry University
Barbara Casu	The University of Reading
Emmanuel Thanassoulis	Aston University
Maria Portela	Portuguese Catholic University
Victor Podinovski	Warwick University

PROGRAMME

Day 0: Saturday, 4 September					
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Day 1: Sunday, 5 September					
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	Keynote 2	*Estimation and inference in two-stage, semi-parametric models of production processes by Leopold Simar*			
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	Keynote 2	*Measuring the efficiency of public services: the limits of analysis by Peter C Smith, and Andrew Street*			
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Applications of rigorous statistical tests using DEA by Rajiv Banker

A. Gary Anderson Graduate School of Management.
University of California, Riverside

Following the statistical foundation provided for DEA in Banker (1993), several studies have explored formal statistical tests based on DEA scores using a rigorous framework. In this talk, I will summarize four common applications where DEA based tests are useful.

1. Simple Tests for Comparison of DEA Scores of Two Groups of Decision Making Units

With a data generating process (DGP) that models the deviation of the output from the best practice frontier as the sum of two components, a one-sided inefficiency term and a two-sided random noise term, conditions are identified under which the two-sample t-test can be used to compare whether the mean efficiencies of the two groups are different. Simulation experiments suggest that these simple tests outperform the tests in Banker (1993) when noise plays a significant role in the DGP, while the Banker tests are superior when efficiency dominates noise.

2. Evaluating Contextual Variables Affecting Productivity Using DEA

Conditions under which a two-stage procedure consisting of DEA followed by regression analysis yields consistent estimators of the impact of contextual variables are identified. Conditions are also identified under which a DEA model of input and output variables, followed by another DEA model of first stage inefficiency scores and contextual variables is appropriate.

3. Statistical Estimation of Technical and Allocative Inefficiency Using DEA

The DEA technical inefficiency measure using total revenues as the single output variable is shown to equal the aggregate technical and allocative inefficiency. This result can be used to estimate allocative inefficiency and construct statistical tests of the null hypothesis of no allocative inefficiency analogous to those of the null hypothesis of no scale inefficiency.

4. Statistical Tests of Productivity and Technical Changes

Formal statistical tests of the occurrence of productivity and technical change estimated using nonparametric methods are now available. Two commonly used tests, Student's T-test and the sign test are shown to be appropriate to evaluate the occurrence of productivity and technical change estimated using DEA.

Estimation and inference in two-stage, semi-parametric models of production processes by Leopold Simar

Technology transfer and receptor capacity issues in Data Envelopment Analysis by Joseph C. Paradi

Centre for Management of Technology and Entrepreneurship
University of Toronto

It is interesting to observe how long it takes to move great technology from the academic to the practitioners' world. In the case of Data Envelopment Analysis (DEA) we believe that here are three reasons for this and explore these issues in this paper. On the one hand, the impediments arise from the research community, which is typically poor at "selling" anything outside of their own circles – the classical "Technology Transfer" problem. Industry participants are notoriously slow to learn new technology, hence the problem of "Receptor Capacity". Moreover, if these were not enough, editors and referees in academic publications, for the most part, insist that only new theoretical developments are suitable for inclusion in peer reviewed journals. Often a paper does not see print in spite of the fact that the authors applied sound, theoretically correct, technology to an interesting real world problem because the referees and editors reject these papers on the grounds that they lack new theoretical development. We will look into what can be done about increasing the receptor capacity of practitioners and the donor attitudes of researchers for the future success of DEA.

Measuring the efficiency of public services: the limits of analysis by Peter C Smith, and Andrew Street

Centre for Health Economics, University of York

Policy makers are increasingly seeking to develop overall measures of the efficiency of public service organisations. To that end, the use 'off-the-shelf' statistical tools such as data envelopment analysis (DEA) and stochastic frontier analysis (SFA) have been advocated as tools to measure organisational efficiency. The analytical sophistication of such methods has reached an advanced stage of development. In this paper we discuss the context within which such models are deployed, their underlying assumptions, and their usefulness for a regulator of public services. Four specific model building issues are discussed: the weights attached to public service outputs; the specification of the statistical model; the treatment of environmental influences on performance; and the treatment of dynamic effects. The paper concludes with recommendations for policy makers and researchers on the development and use of efficiency measurement techniques.

Keywords: public services, efficiency measurement, stochastic frontier analysis, data envelopment analysis, public policy.

Parallel Sessions

Sunday 05 September 2004: 11.00 – 12.15

Stream A11– Theory I

P-006

The assessment of cost efficiency allowing for adjustments to input prices.

Camanho, A. and Dyson, R.

This paper discusses the assessment of cost efficiency (CE) using Data Envelopment Analysis (DEA) models. The concept of CE can be traced back to Farrell, who originated many of the ideas underlying efficiency assessments. The Farrell CE measure can be interpreted as a measure of the potential cost reduction achievable through adjustments to input levels, given the current prices paid by the DMU.
To date, the limitations of the CE measure have been given limited attention in the DEA literature. The cost efficiency measure as usually defined can be of limited value in actual applications due to data requirements and unjustifiable assumptions: exact knowledge of prices is difficult and prices may be subject to variations in the short term. This paper highlights some shortcomings of the Farrell CE measure in situations where prices differ between DMUs and develops a new approach that complements the traditional DEA CE models by relaxing the fixed prices assumption.
The main contribution of this paper can be summarised as the development of an enhanced DEA measure for the assessment of CE in scenarios where price adjustments are possible. In these circumstances, in order to become efficient and produce with minimal cost, the DMUs may have to adjust both input and price levels.
The approach developed in this paper differs from the usual DEA cost efficiency approach because the Farrell CE measure only reflects input efficiency, i.e., the potential cost reduction achievable through input adjustments, given the prices currently paid at each DMU. This measure does not reflect the inefficiency associated with paying prices above the levels observed in other DMUs. The efficiency measure developed in this paper reflects the differential between the total cost of a DMU and the minimal cost of output production estimated from the analysis of other DMUs. Therefore, it can complement the Farrell CE assessments as it includes a new efficiency component (“price efficiency”) that captures the extent to which a DMU has adequate input prices under the current market conditions.
In scenarios of variable prices, in order to become efficient and produce with minimal cost, the DMUs may have to adjust both input and price levels. The targets obtained as by-products of the approach developed in this paper always correspond to input and output combinations within the production possibility set and avoid prices that are below the levels observed in the market.
The applicability of the approach developed in this paper is illustrated in the context of a real-world efficiency assessment of a bank branch network.

Keywords: Data Envelopment Analysis, Cost Efficiency, Adjustable prices.

P-089

Distance maximization in DEA

Glaser B, Kleine A

In DEA a scalarizing function reduces all numerical information of decision making units to an efficiency measure or inefficiency measure respectively. For locating efficient alternatives MCDM generally postulates the concept of distance minimization, for which an unattainable but desired point far beyond the efficient frontier serves as a reference point (utopia point). With regard to this point distance is minimized measured by means of classical measures based on the well-known Lp-norm. Diametrically opposed is the concept of distance maximization, which uses as a reference point a feasible alternative, i.e. a point on or below the efficient frontier. With this point as an anchor, distance maximization is oriented towards the efficient frontier as a best imaginable practice accounting for potential improvements. As the concept of distance minimization is not directly applicable to DEA, we introduce so-called dist-max functions. We utilize a general DEA model, which maximizes distance between a given production and the efficient frontier. On these grounds we present relations to well known DEA models and in addition develop some promising new ones.

Keywords: Distance Maximization, General DEA Model, MCDM

P-151

A New approach to determine efficient DMUs in DEA models with using inverse optimization

Amin Gholam R, Raissi S.

This paper proposed a new approach for determining efficient DMUs in DEA models with using inverse optimization and without solving any LPs. It is important to compare computational performance of solving the simultaneous linear equations with that of the LP, when computational issues and complexity analysis are at focus.

Keywords: Data Envelopment Analysis(DEA), Decision Making Units (DMUs), Inverse Optimization

Stream B11 – Banking I

P-031

Banking efficiency and productivity analysis: Inputs and outputs, and the structure of bank production

Kenjhegalieva K.A. and Weyman-Jones T.G.

The literature on the efficiency and productivity analysis in the banking industry is vast and rapidly growing. However, this research differs considerably in how banks' inputs and outputs are defined and measured. These differences reflect the preference of researchers for different models of banking production, such as the intermediation, production and value-

added approaches. Generally inputs in these models are taken from a range of flow variables in the income account, while outputs are taken from a range of stock variables on both sides of the balance sheet. The comparison is further complicated by the fact that researchers often use different databases, which almost inevitably leads to different definitions and measurement of input and output variables, and of the types of banks, e.g. savings banks, commercial banks, retail banks and investment banks. For example, it is difficult to tell whether a certain choice of variables has been dictated by 'pure' theoretical considerations or simply by the issue of data availability. In this paper we combine and examine the research findings which employ the same database - Bankscope. The major objective is to systematically examine the use of flow and stock measures of inputs and outputs in different modelling frameworks of banking efficiency. By doing that we believe that any differences in the choice of approach of inputs and outputs definitions are primarily conceptual and therefore can be compared more effectively.

Keywords: Banks, Efficiency, Productivity, Inputs and Outputs, Structure of Bank Production

P-015

Risk and technical efficiency in the Tunisian banking industry

Mohamed E. Chaffai, Sémia Lassoued

Over the last 15 years, the emergent developing countries' banking industry has encountered serious problems of non-performing loans (NPL). This fact has led to increased attention toward the issue of the risk's effect on the production process. In fact, the business of a banker involves assessing, transforming and managing many kinds of risks (credit risk, liquidity risk and insolvability risk). However, the risk factor affects banks performance via different ways. First, as the insolvability risk raises the rates that the bank pays to its depositors, it will increase the funding costs and hence imply a deterioration of the bank performances (Mester, 1993). Moreover the credit quality is adversely related to costs and revenues (Berger and Deyoung, 1997). Hence risk seems affecting both the costs and the profits of the banks. This suggests that any study of efficiency ignoring risk will be misleading.

Besides the developing countries were tackling a NPL problem, the NPL ratio of banks in these countries is very high in comparison to developed countries. So taking in consideration this phenomenon is important while measuring bank efficiency in these countries. However, empirical studies on bank efficiency measures controlling for risk, focused on developed countries only, Berger and Mester (1997) for USA banks, Dietsch (1996) for the French banks, Altumbas et al (1999) for the Japanese banks. So measuring the bank efficiency controlled by risk in Tunisia, will contribute to this empirical literature.

Several approaches are commonly used to incorporate risk in the banker's production process behavior. The first one introduces variables controlling for risk such as NPL, or equity in the cost frontier (Berger and Mester, 1997, Mester, 1996, and Altumbas et al, 1999). The second approach uses the AIDS (Almost Idea Demand System) model by allowing banks' managers to trade reduced profitability for lower risk (Hughes et al, 1996). The third approach is based on the distance function with undesirable outputs specification (Färe et al, 1989). Unfortunately, this methodology has been exclusively used to the polluting industries and to agriculture. Few papers adopted this methodology to the banking sector by considering NPL

as an undesirable output, while the other outputs like loans, deposit and investments as the good outputs (Chung, 1999, Li et al, 2002, and Dangili et al, 2002).
This methodology allows constructing the production frontier by increasing the good outputs and decreasing the bad outputs. So technical inefficiency deduced by this methodology control for risk.
Our objective in this paper is twofold: First we propose measures of Tunisian bank efficiency controlled for NPL. Technical inefficiency is measured by estimating a parametric directional distance function. The second objective of this paper is to compare the technical efficiency scores by comparing two methodologies. We estimate a cost frontier, and we introduce NPL to control for risk. We derive cost efficiency score which is decomposed into technical efficiency and input allocative inefficiency. Finally we compare the technical efficiency scores obtained by the two methodologies (the directional distance function, and cost frontier model). The comparison would be interesting because the directional distance function is sensitive to which direction is used to increase the good output and to decrease the bad ones.
We have a sample of 11 commercial banks operating in Tunisia over the period 1989-2002. We retain only the banks for which we observe a regular activity over the studied period. Our specification includes three good outputs: total loans (short and long term loans), investment and demand deposit, one undesirable output: allowances for loans losses, and three inputs: labour, capital and deposit. The data source is the Tunisian Banking Association
We used the directional output distance function model that allows treating risk as an undesirable output. We applied three versions of this function by choosing several directions. The first direction allows banks to increase simultaneously and proportionally the desirable and undesirable output. The second direction retained allows the manager to increase the desirable output holding constant the risk's level. The third direction allows bankers to contract the undesirable output and raise at the same proportion the desirable outputs.

P-040

Efficiency of the Polish banking sector – assessing the impact of transformation

Nellis J.G., Zarzecki D., Guzowska M., Kisielewska M.

The Polish banking sector has gone through three major developmental stages since the beginning of the country's transformation process in 1989. The first stage, from 1989 to 1992, involved a dramatic increase in competitive pressures although this was not underpinned by the establishment of a robust legal and regulatory framework. Between 1992 and 1997 there was a restructuring of financial institutions as well as re-capitalisation of banks leading to a more competitive environment. Since 1998 strategic investors have become progressively more active, embracing the benefits of new technologies in the pursuit of increasing margins in a market that is growing in competition. In the build-up to Poland's accession to the European Union on 1 May 2004, new directions have been implemented in terms of banking supervision with the regulators and market players supporting the efforts concerned with establishing stability in the financial sector. In this context the pace of competition in the Polish banking sector has intensified in both the corporate and retail markets. This has led to extensive structural changes which have stemmed largely from the inflow of foreign-controlled banks. Today, more than 75% of the capital in the banking sector is foreign-owned.
The pace of change has stimulated the development of new competitive strategies, increased investment in human resource skills and branch networks as well as the use of technology in money transmission services. The domestic banking industry has sought to reduce

inefficiency – which has resulted in the closure of many of the least efficient banks and increased merger activity in efforts to improve economies of scale and scope. This paper analyses the performance of the Polish banking industry since the mid-1990s in order to assess the extent to which efficiency has improved. DEA is employed to examine the cost structure, profitability and thus the efficiency of the commercial banks. The results have implications for the future of the industry as it adapts to the new competitive pressures which will inevitably result from Poland's membership of an enlarged Single European Banking sector.

Keywords: Polish Banking Sector, Efficiency, Costs, Profits, DEA, Malmquist Index

Stream C11 – Applications I

P-113

Using DEA to measure performance of Science parks: Case of Iran

Shahmohammadi F, Charmi M

Science parks (including science parks and incubators) have been a very good tool to create opportunities of development in different aspects of technology. Since the creation of this phenomenon in the US, many countries commenced to develop such places to achieve their goals in technology and generally in deferent sciences. As a developing country, Iran has an approximately 2 decades of experience in this regard. Many organizations involving science parks in Iran do not know the efficiency of the activities they do and how their deeds can be improved through benchmarking of their programs. Not all science parks have been successful in Iranian context and of course in general. The origin of the study goes back to the need of organizations playing major role in development of science parks. As much costs incurred in creation of science parks, managers of different science parks should be well informed from each other work. In this paper appropriate inputs and outputs to benchmark science parks have been developed. Using an apposite model from DEA pool, formulation has been formed and run in a computer program. The nature of inputs and outputs and also the model are very elaborately-chosen ones. That is mostly because of science parks are very specific decision making units. These units are not ordinary DMU's like banks, hospitals, universities etc. They are different because of their goals, nature, environment, expectations, roles in development of countries and some other characteristics that make differences more lucid. The upshots of the runs have been analyzed and pertinent solutions have been addressed. The essence of the present paper is to introduce DEA as a very useful means to measure the relative efficiency of science parks in Iran and benchmarking them with each other to minimize costly consequences of blinded-eye developed science parks. The results of the study show that science parks can be developed in a better way by altering the relevant inputs and outputs defined for benchmarking them. Furthermore, it is concluded that Science parks could be managed much more better than what today are managed.

Keywords: DEA, Science Parks efficiency, Performance, Development

P175

Does the DEA efficiency score predict future profitability

Banker, Rajiv D. and Mashruwala, Raj

A number of managerial decisions require the prediction of future earnings. Therefore, a measure that is able to predict future earnings will be a valuable addition to the management reporting system. Literature that examines the time-series properties of earnings shows that past and current earnings can be used to predict future earnings. Several papers have documented that earnings have both permanent as well as transient components. The transient component of earnings makes earnings a 'noisy' predictor of the future earnings. Thus, a measure that captures the permanent component of earnings will be a better predictor of the future earnings stream.

The concept of relative efficiency of a business unit refers to the intrinsic ability of a business unit to generate the maximum output from available resources when compared to similar units. This ability of the business unit is likely to persist in the future, unlike profit which is likely to be affected by 'noise' in the business environment. This implies that a measure of the relative efficiency of a business unit is likely to be able to predict future profits. In the first section of the paper we utilize the theory of momentum accounting to model the relationships between efficiency, past profits and future profits which provides a framework for our empirical tests.

We use a two-stage approach to examine this issue using data from more than 1000 retail outlets. In the first stage we calculate the efficiencies of all outlets in the sample for the particular year using an operations-based procedure known as Data Envelopment Analysis (DEA). The DEA model comprises a single output measured by the annual sales revenues of each outlet, and four inputs: the number of non-supervisory staff, the number of supervisory personnel, the space occupied by each outlet and the average inventory of merchandise. In addition we include a contextual measure to capture differences in the environment faced by urban and other outlet locations. In the second stage we use the efficiency scores obtained using the DEA procedure in our empirical models to predict future profit, controlling for other financial predictors of future performance. Our results confirm our hypothesis that the DEA efficiency measure is able to predict future profit even after controlling for current and past profits. This result holds when alternative specifications of the model are tested.

P119

Measuring Port performance effectiveness with Data Envelopment Analysis (DEA)

R. Nugroho Purwantoro

Productivity evaluations for organizations with multiple inputs and outputs are extremely complex, thus it's difficult to make comparisons between the organization working units. For that reason, this study uses Data Envelopment Analysis (DEA), a non-parametric approach based on linear programming technique. DEA works by identifying the working unit to be evaluated, and the kind of input and output that working unit uses & produces. DEA will form efficient frontier for available data set and compute productivity score for each working unit that in case not included in the efficient frontier.

The topic of the study is how to measure performance of 24 Indonesia public ports in 2002 by using Data Envelopment Analysis (DEA). Application of DEA enables the study for using multiple input & output variable for evaluating unit and also directly comparing the result, it can happen because DEA give 1 (one) composite score for every evaluated port when all input and output data are processed simultaneously. DEA will indicate which port that producing output effectively or ineffectively by considering its input level.
From calculation result, 8 ports not optimising their input in producing output compare with the other 16 ports in 2002 from evaluated data set.

Keywords: Data Envelopment Analysis, Port productivity, BCC-O

Stream D11 – Health I

P-137

Data Envelopment Analysis improves expense reduction in hospitals

Bernardes O. and Mariola Pinillos

The purpose of this paper is to present an instrument to promote the reduction of health costs through the combination of a method of nonparametric frontier estimation and the information of the manage accounting.
In other to illustrate the potential of this instrument a comparison of 58 Portuguese hospitals, which provide in-patient treatment for general surgery, is carried out.
The goal is to make a useful instrument which could allow the hospital administration to identify the deficiencies that affect their resources and the causes of these deficiencies, so that they can initiate corrective actions to eliminate or at least reduce them. As regards the National Health Service, this instrument should allow the comparison between different adopted contexts, by stimulating new policies which reduce the health costs, or by maintaining the costs, while providing better services for all citizens.

P-099

Efficiency of treatment of diabetes mellitus in general internal medicine departments in Germany: A DEA-bootstrap approach

Matthias Staat

I analyze data on diabetes mellitus patients who were treated in German hospitals in 1994. To generate a data set of comparable observations, only internal medicine departments which treated at least 100 cases of diabetes mellitus are considered. This leaves 185 departments. Cases are identified on the basis of a 3 digit ICD code. The information available comprises the per diem of the respective departments as well as the length of stay (LOS) by ICD. The hospitals are remunerated with the per diem for cases of diabetes. All cases are classified into seven age clusters. It is also known how many cases underwent surgery and whether the department provides intensive care. On the basis of these data, an input oriented VRS-model is specified. Per diem and LOS function as inputs, the number of cases by age cluster, the number of cases which underwent surgery as well as and indicator for intensive care beds serve as outputs. These indicators are used to model intra-ICD variation with respect to the complexity of the cases.

Only nine departments are rated as efficient when the standard DEA approach is applied; the average efficiency is 72.1%. The implication of the standard efficiency estimates is that diabetes cases could have been treated for just over half of the observed 2,000? when input slack is taken into account. Confidence intervals for the efficiency scores were calculated applying the DEA-bootstrapping procedure introduced by Simar and Wilson (1998). Less than 30 departments have an efficiency score that is not significantly different from unity (confidence intervals centred on the original estimates, about 1/3 of the DMUs fail the MSE criterion). The average bias corrected efficiency is 62.71%.

Keywords: DEA, bootstrap, diabetes

Stream E11 – Environment

P-036

Materials balance based modelling of environmental efficiency

Lauwers L, Van Huylenbroeck G, Coelli T.

A new method for analysing environmental efficiency, based on the materials balance, is proposed. With this method, an environmental allocative efficiency measure can be defined analogously to the more commonly used economic allocative efficiency. Nutrient surplus in pig fattening, a typical balance indicator, is used to illustrate the concept in a "two input one output" case. The materials balance based efficiency analysis is elaborated using data envelopment analysis (DEA). Results are compared with those of more common, merely input or output oriented DEA approaches. A main conclusion is that, ignoring the balance feature of environmental issues such as nutrient surplus might be a main reason why traditional integral analyses of economic and environmental efficiency yield contradictory conclusions.

Keywords: nutrient balance, data envelopment analysis, environmental and economic allocative efficiency

P-045

Measuring environmental efficiency of products using DEA

Kortelainen Mika, Kuosmanen Timo

In numerous studies environmental efficiency is measured by using DEA (see e.g. Färe et al., 1989; Färe et al., 1996 and Tyteca, 1996). However, these earlier studies of measuring environmental efficiency in the DEA framework have focused exclusively on the production process, while the environmental efficiency of the products themselves has been neglected. On the other hand, the earlier studies that use DEA for product evaluation tend to evaluate product characteristics from the engineering or marketing perspective, paying little (if any) attention to environmental sustainability. In practice, even nearly identical products (e.g. washing machines) can differ considerably from one another with respect to their environmental effects and efficiency.
In this paper, the measurement of environmental efficiency of products is discussed in the DEA framework. Our approach builds on Lancaster's (1966) approach to consumer choice

where individual's preferences are defined with respect to product characteristics, which have been operationalized in the DEA context by Doyle and Green (1991), Odeck and Hjalmarsson (1996) and Staat et al. (2002), among many others. We believe that combining the product evaluation perspective to the measurement of environmental efficiency presents a valuable new application area for DEA. The approach is illustrated by an empirical application to the measurement of environmental efficiency of automobiles.

Keywords: environmental efficiency, Data Envelopment Analysis, product evaluation, environmental pressures, automobiles

P-025

Technical progress, efficiency change and productivity in the presence of environmental factor in Chinese industry

Donglan Xu

This study employs a Data Envelopment Analysis (DEA) approach to analyze total factor productivity, technology and efficiency change in Chinese industry production from 1993 to 2002. According to the development level of economy, 25 provinces in China are classified into three regions: The Eastern Region, the Central Region and the Western Region. The Eastern Region is the most developed region, followed by the Central Region and the Western Region. The traditional Malmquist productivity measures take account of inputs and desirable outputs and do not allow for undesirable outputs. We extend the Malmquist productivity indices so that they are able to deal with pollutants besides inputs and desirable outputs. The extended Malmquist productivity measures are also decomposed into two components: technical change index and efficiency change index. We respectively calculated the traditional and extended Malmquist productivity indices in order to investigate the change of three variables (technology, efficiency and productivity) in the two different situations and the influence of environmental factor on each variable. As a result, we know that total factor productivity has risen in all of regions without considering pollutants during the 1993-2002 period. For the eastern and central regions, both of technical progress and efficiency change simultaneously contributed to the increase of productivity. But for the Western Region, the growth of productivity was attributable to technical progress. Efficiency change had minus contribution to it. Under considering pollutants, the results show that total factor productivity has risen in the eastern and central regions, while that has not improved in the Western Region. The industrial productivity growth in the Eastern Region was mostly attributable to technical progress. The Eastern Region seems to have a great potential to increase productivity through improved technical efficiency. For the Eastern Region, efficiency decreased due to the introduction of environmental factor and this change gave negative influence on productivity. However, technical progress still contributed to the increase of productivity even if considering environmental factor. For the Central Region, the contributions of technical progress and efficiency to the productivity growth were almost the same. There is no change between two cases for the Central Region. Environmental factor resulted in larger change for each variable for the Western Region. The deterioration in both efficiency and technical progress caused decrease in productivity. Productivity and technical progress decreased during the 1993-2002 when considering pollutants. It is different from another case. Efficiency gave negative impact on productivity in both of cases.

Keywords: Technical Progress, Efficiency Change, Productivity, Environmental Factor, Chinese Industry

13.45 – 15.00

Stream A12 – Theory II

P-083

Constructions of two-dimentional and three-dimentional cross-sections of the multidimensional frontier in DEA and productivity analysis of Russian banks

Krivonozhko VE, Utkin OB, Zharkov ID, Lychev AV, Safin MM.

In this work, we present a family of parametric optimization methods, which allows us: (a) to apply to DEA well-known functions of economic theory such as production function, isoquant, isocost and isoprofit; (b) to visualize the frontier in a multi-dimensional space of inputs and outputs; (c) to optimize a production unit's behaviour in the multidimensional space of inputs and outputs; (d) to calculate various economic indices such as marginal rate of substitution, marginal rate of transformation, scale elasticities and so on. In DEA scientific literature there were some attempts to identify efficient surfaces of the frontier. In our work, we propose to construct intersections of the frontier with three-dimensional affine space on the basis of parametric optimization algorithms. Thus we can avoid exponential complexity under construction of three-dimensional sections of the frontier. With the help of this approach we can investigate production units behaviour locally and globally. We apply our approach to efficiency analysis of Russian banks.

Keywords: Parametric optimization methods, Marginal rates, Russian banks.

P-053

A new algorithm for ranking efficient decision making units in Data Envelopment Analysis

Najizadeh R

While basic DEA models have many desirable features that have contributed to their rapid adoption by practitioners, there remain some weaknesses with the original models. For example, all efficient Decision Making Units (DMUs) have the same efficiency scores equal to one in both the CCR and the BCC model. Therefore, it is impossible to rank or differentiate the efficient DMUs with the CCR and BCC models. However, the ability to rank or differentiate the efficient DMUs is of both theoretical and practical importance. Theoretically, the inability to differentiate the efficient units creates a spiked distribution at efficiency scores of one. This poses analytic difficulties to any post-DEA statistical inference analysis. In practice, further differentiation among efficient DMUs is also desirable and even necessary in many cases.
To overcome this weakness, Andersen and Petersen presented the Modified DEA (MDEA) method. The core idea of MDEA is to exclude the DMU under evaluation from the reference

set and therefore, the efficient DMUs will, in general, have different efficiency scores. but it can be unstable when one of the DMUs has a relatively small value for some of its inputs. This paper proposes a new ranking algorithm by determining virtual optimum DMU that can be used for ranking efficient DMUs in CCR input oriented model by DEA method and removes the foregoing difficulty.

Keywords: Data envelopment analysis (DEA), Efficiency, Ranking

P-108

Estimating potential gains from reallocation of resources

Vladimir Nesterenko and Valentin Zelenyuk

In this work, we merge the results of aggregation of efficiency indices obtained by Ly and Ng (1995) and Färe and Zelenyuk (2003) to introduce a new notion of efficiency of a group, related to optimality of allocation of inputs across the units within a given group. We also extend the bootstrap approach of Simar and Zelenyuk (2003) for the context of the new efficiency measure and demonstrate our methodology in a few simulated data generating processes.

Stream B12 – Banking II

P-055

The application of DEA in bank efficiency evaluation in Bulgaria, Romania and Croatia

Hadjiev, V, Stancheva, N

We estimate the operational efficiency of 10 major Bulgarian banks for the 2003. The paper suggests a comparison with the results of the same DEA evaluation results in other two East European countries, aiming EU accession - Romania and Croatia. The data are collected from the official year reports of the Central Banks of the three countries. A survey of DEA studies in Bulgaria, Romania and Croatia is made.

Keywords: Bank Efficiency, CCR output oriented model, East European Countries

P-138

Assessing financial risk tolerance of portfolio investors using DEA

Joseph C. Paradi and Parisa Hosseini Ardehali

The dilemma of how to decide what investment strategy a person should adopt has been a problem for some time. For high net worth individuals the problem is addressed by their personal investment counsellors or highly trained securities advisors/brokers. But for the "ordinary" wo/man on the street who is investing only a few thousand dollars, the problem of what best fits them is a difficult one. To make matters worse, the Canadian Government has enacted the "Know Your Client" Act which requires that all investment dealers and vendors of securities must know their clients and be responsible for the client's investment strategy.

Such strategy must match the client's needs and these needs are determined on a "common sense" basis - the client can always opt out by a written declaration. For example, an 80 year old's investment strategy will be quite different than that of a 30 year old. We utilized DEA in a very novel manner by applying it to data collected world wide using a 24 question document completed by small investors to large ones. The model used predicts the risk profile of the investor which will range from very conservative to very risky. The prediction is validated by comparing the outcome to the commercial system in use by numerous investment advisors.

Keywords: DEA, Risk assessment, investment strategy

P-074

Measuring portfolio efficiency of mutual funds: A stochastic dominance -based DEA approach

Kuosmanen, T.

This paper presents a new approach for measuring portfolio efficiency of mutual funds using Data Envelopment Analysis (DEA). The approach accounts for portfolio risk by applying the general Stochastic Dominance (SD) criteria to the entire distribution of returns. Our static measure of portfolio efficiency also accounts for portfolio diversification, similar to the standard Mean Variance (MV) model. The main difference between our SD-based DEA model and the MV model is that the MV model limits itself to the first two moments of the return distribution while our DEA model accounts for the entire return distribution. We illustrate the approach by an empirical application to a sample of US based mutual funds to investigate whether socially responsible mutual funds differ from traditional equity funds in terms of their portfolio efficiency.

Keywords: Data Envelopment Analysis (DEA), Stochastic Dominance, diversification, portfolio efficiency, socially responsible investing

Stream C12 – Applications II

P-071

Efficiency of Czech insurance companies

Bogusevicius J, Lasaite D, Pranculis A, Skuodas S.

The paper aims at an intra-industry comparison and overall assessment of efficiency in the Czech insurance sector. In particular, the relation of efficiency to size and activity of insurance companies is examined, with high emphasis being put on potential economies of scale. Efficiency is quantified by using the Data Envelopment Analysis (DEA) technique. The results provide a valuable insight into the current efficiency level of the Czech insurance sector. Large companies exhibit a rather clear pattern of higher efficiency as compared to smaller ones. As theoretically expected, this could be attributable to the fact that large insurers utilize economies of scale, whereas small companies experience costs from operating under increasing returns to scale. The growth or consolidation of smaller market participants thus is likely to benefit the sector as a whole. Composite insurers are also found to be more

efficient than specialized firms, yet specialized insurers, despite being less scale efficient, try to compensate for lower scale efficiency by adopting the best available technology and outperforming composite insurers in terms of pure technical efficiency. By estimating the Malmquist index an observation was made that the level of efficiency is slightly growing during the sample period of 2001 to 2002. The research is unique in a way that no previous study to our knowledge has carried out a methodologically similar research for insurance sector in the Czech Republic.

Keywords: Insurance efficiency, Malmquist index, Economies of scale in insurance sector, Czech insurance sector, Relationship between company size and efficiency, Relationship between company activity and efficiency, Returns to scale.

P-073

Slacks based efficiency measurement: an application to electricity networks

Julia Boucinha, Celia Godinho,Catarina Feteira Inacio, Thomas Weyman-Jones

In managing a group of integrated regional electricity networks there is an interest in their comparative performance. Even if the number of networks is low, the integrated organisation may be able to collect network performance data, including a quality of supply measure, on a homogeneous basis with feedback from the network managers. This situation makes a DEA approach to performance measurement particularly suitable. However, with a low number of networks, standard radial efficiency measures based on input or output distance functions may produce a large number of Farrell-efficient units. There are many methods for providing both more discrimination and useful management information, including super-efficiency analysis, and weight restrictions. In this paper, we apply the slacks based methodology recently suggested by Tone (2001, 2002). This is non-radial, units invariant, and monotonic in the values of the slack variables, and produces percentage efficiency scores which cannot exceed radial efficiency scores under a wide set of assumptions. The primal envelopment model is clearly related to the standard DEA framework, while the dual multiplier model has an intuitively appealing profit maximisation interpretation. The model can accommodate both super-efficiency and assurance region weight restrictions. We apply this methodology to a carefully monitored data set of 14 electricity networks within a single country, and compare the results with those from the CCR-BCC radial efficiency models. Finally, we suggest a GAMS implementation for the Tone (2001, 2002) models based on extending a well known GAMS DEA formulation.

Keywords: DEA efficiency, slacks, units invariant, electricity networks

P-115

Information content of an efficiency measure for predicting operating income

Abad C., Banker R., Mashruwala R.

Prior research has shown that current operating income may not be a perfect predictor of future operating income because of transitory economic conditions that are reflected in current earnings. Therefore a measure that is able to capture the persistent component of firm performance may have predictive ability over and above past earnings information. In this paper, we evaluate the information content of a DEA-based efficiency measure for predicting

future operating income after controlling for information contained in current operating income. Since relative efficiency is an attribute inherent to the firm it remains unaffected by economic events such as input/output prices that add noise to the operating income number. Such a measure, thus, may be able to provide additional information when using along with current earnings to forecast future earnings.
In the first stage of our analysis we use DEA to determine the relative performance of a sample of 266 large firms in Spain during the period 1995 to 1997. Inputs and outputs are characterized in terms of items from the income statement. Inputs of firms consist of labor (personnel expense), materials (cost of materials consumed), capital (depreciation expense), and support overhead (other operating expenses), while output is characterized by sales revenue. In the second stage of our analysis we estimate regression models to assess the information content of this DEA measure of relative efficiency in forecasting the following year operating income.
Our empirical results show that the efficiency measure has significant ability to predict the following year operating income even after controlling for current operating income. The results are robust to the inclusion of the prior year operating income in the estimation model.

Keywords: two-stage analysis, earnings prediction

Stream D12 – Education I

P-078

A model for teacher qualification policies assessment

Bonilha U.

This paper presents the conceptual basis and the main results of the model for teacher qualification policies assessment developed in Bonilha (2002). That model uses the Data Envelopment Analysis approach to construct effectiveness frontiers that represents the short run and the long run equilibrium conditions and that identify effective and no-effective teachers. Statistics tests were used to verify and to control the school climate and the family environment influences on student's performance. The main focus of the model is to identify the most effective ways to improve teacher's performance.

Keywords: teacher qualification policy effectiveness

P-059

Secondary schools efficiency in the Czech Republic

Oleksandr Stupnytskyy

Importance of education for workers productivity and economic growth was established in many previous studies; as well as importance of school efficiency analysis for information of educational policy. For the case of transition economies of Central Europe there are relatively few studies on educational efficiency. The aim of this paper is, therefore, to add more information on this topic and using extensive data for the case of the Czech Republic,

estimate efficiency of secondary schools and analyze the effect of local and school characteristics on the school efficiency.
The first of these aims is achieved by means of Data Envelopment Analysis (DEA), a method specially designed for evaluation of performance of public institutions that use multiple inputs and produce multiple outputs. In estimating efficiency the DEA method does not require specification of relative weights of the inputs and outputs. Since such weights are difficult to specify, the DEA approach provides a valuable alternative technique for estimation and comparison of school productivity.
The second aim of the project is to identify determinants of school efficiency. This is achieved by means of statistical analysis. This part focus on the effect of different regional and school characteristics on school efficiency estimated in the first part of the analysis. Among local characteristics are rate of local school competition, and type of community; school characteristics include school ownership, organization, and curriculum. The project focuses on secondary education in the Czech Republic. It uses unique data set, which covers all secondary schools and their students in the country. This provides the most complete information on school characteristics and student achievements, and allows precise estimation of school efficiency.
The project also analyzes if there is a significant variation in efficiency by schools and regions and estimate what would be the total gain in student achievements if all schools operate efficiently.

Keywords: Educational efficiency, Educational Policy, Funding and Outcomes, Data Envelopment Analysis

P-124

Data Envelopment Analysis of relative efficiencies of Institutions of Higher Learning

Joseph Calhoun

Charnes, Cooper, and Rhodes (1978) created Data Envelopment Analysis (DEA) for application to nonprofit entities as a means to identify inefficiencies of inputs and outputs. The first application of DEA was to public schools in the evaluation of Program Follow Through (Charnes, Cooper, and Rhodes, 1981). This paper applies DEA to four-year institutions of higher learning (IHLs).
Two distinguishing characteristics of this analysis are the comprehensive nature of the data and the new way of grouping institutions. Previous studies with applications to U.S. higher education have used a relatively small sample of institutions. The analysis in this study uses the largest sample to date, which includes 1,323 institutions. More specifically, three subsamples exist: 222 doctoral, 507 master's, and 594 bachelor's-granting institutions. Data obtained from the National Center for Education Statistics for academic year 1995-96 are used to calculate efficiency scores and make comparisons. Additionally, institutions are separated in a new way. This study separates IHLs by the percent of unrestricted revenue; those with unrestricted revenue above a certain threshold are grouped together and those with unrestricted revenue below that threshold are grouped together.
I develop one model with six inputs and seven outputs. Results are obtained by employing two different DEA methods. The first method generates a single production frontier for each subsample and then groups institutions for comparisons. For example, a single frontier is generated using all doctoral-granting IHLs and an efficiency score is calculated for each

institution. The IHLs are then separated into public and private groups and mean efficiency scores are calculated for each group. The mean scores are used to determine which group is relatively more efficient.
The second method generates separate (i.e., first-stage) frontiers for each group in a subsample. The Charnes, Cooper, and Rhodes (CCR) (1978) ratio then projects each institution onto its frontier. The two groups are then combined and a single (i.e., second-stage) frontier is generated to make comparisons. For example, separate (first-stage) frontiers are generated for public, master's-granting institutions and private, master's-granting institutions. The CCR ratio then projects each IHL onto its respective frontier. The institutions are then combined to generate a single (second-stage) frontier. Then comparisons between public and private are made.
When using the first DEA method that allows program and managerial inefficiencies to be present, I find no statistical difference between any of the groups for doctoral-granting IHLs. For master's-granting and bachelor's-granting IHLs, those below 90\%, 85\%, and 80\% unrestricted revenue have higher average efficiency scores than those above. For master's-granting IHLs, public institutions have higher average efficiency scores than private.
Given the results from this DEA method, I postulate that those HLs with a smaller percentage of unrestricted revenue are, on average, more efficient than those IHLs with a higher percentage because the restricted nature of the revenue serves as an accountability and efficiency control measure on the managers and the institution. The restricted revenue essentially negates any managerial inefficiency that might exist. Consider an IHL with a particularly inefficient set of presidents and deans. If most of their revenue is received as restricted, they have little discretion of how to allocate their expenditures. The donor has decided for them. Hence, their inefficient behavior is minimized or eliminated, dependent on the actual level of restricted revenue. In essence, the donors are choosing from the available production functions.
When using the second DEA method that eliminates managerial inefficiencies, I find private IHLs obtain a higher average score than public for all three subsamples. I find no statistical difference between those below the 85\% threshold and those above for doctoral-granting and master's-granting IHLs. However, for bachelor's-granting IHLs, those above the threshold obtain a higher average score than those below. For all groups in all three subsamples, the average scores increase from the first-stage frontiers to the second-stage.
Since managerial inefficiencies have been eliminated, this implies that institutions that operate with a higher percentage of unrestricted revenue exhibit higher program efficiencies.
The presidents and deans seem to have chosen a relatively optimal production function for their institution. This should be the case since they have more discretion over their allocation of expenditures. They should be able to more easily and quickly respond to their environment and produce outputs more efficiently than those institutions limited by their revenue flexibility.
The data also suggest, however, that managers with a lot of unrestricted revenue do not use it efficiently. The first-stage frontier results indicate low average scores for IHLs with high percentages of unrestricted revenue. The average scores rise dramatically when managerial discretion is eliminated from the decision-making process.

Keywords: Higher education efficiency

Stream E12 – SFA

P-049

Stochastic frontier production efficiency evaluation of market assisted land reform in NE Brazil

Rocha de Souza M., Souza Filho H.M., Buainain A.M., Silveira J.M., Magalhaes M.M.

We evaluate the "Cedula da Terra" Pilot Project, a land reform project whose conception, mechanisms and operational structure is different from traditional agrarian reform based on expropriation. The land distributed by the project, is first acquired by the agricultural producers associations, and a given set of incentives is established to obtain a better efficiency use of resources. The main objective of this article is to characterize the sources of technical and allocative inefficiency from a cross section of 309 beneficiaries from five states in NE Brazil. We estimated a potential production frontier following the methodology of Battese and Coelli (1995), using the software Frontier 4.1. (Tim Coelli, 1996). The main conclusion is that technical assistance, human capital (years of schooling) and better access to credit reduce inefficiency, or thus increase technical and allocative efficiency of the beneficiaries. So, one should increase credit and technical assistance as first line priorities and reinforce education policies as a longer term priority. The "Cedula da Terra" pilot project is further described in Buainain et al. (1999, 2000).

Keywords: Land reform, Market Assisted Agrarian Reform (MAAR), human capital, technical assistance, credit, Stochastic frontier efficiency analysis, Brazil, Programa Cedula da Terra (PCT)

P-067

Benchmarking the efficiency of Philippine electric cooperatives using Data Envelopment Analysis and Stochastic Frontier Analysis

Rouselle F. Lavado

This paper attempts to determine alternative methods of benchmarking the efficiency of electric companies (ECs) to aid the regulator in crafting policies that will entice them to pursue more efficient production. The purpose of this paper is to make a contribution to the method of assessing the efficiency and determining avenues for cost reduction of ECs in the Philippines. Using a panel composed of 119 cooperatives from 1990 to 2002, a cost function was estimated to identify appropriate cost variables that will determine the frontier. It was found out that the main cost drivers (as represented by total operating and maintenance costs) are total sales, prices of labor and capital, distribution network, transmission capacity, actual billed customers, service area, demand structure, and system losses. Based on this specification, efficiency frontiers are computed using Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The efficiency of each cooperative was then ranked and compared for consistency checks. The SFA reports that on the average, ECs are 34 percent away from the cost frontier while that of DEA estimates 42 percent. The panel data also allowed for DEA to calculate Total Factor Productivity (TFP) changes based on the Malmquist index. On the average, TFP increased by 1.7 percent from 1990 to 2002. The rankings and productivity values will prove to be useful for the energy regulator in determining efficiency targets. The fact that DEA and SFA are based on theoretically determined cost function will lead to results that are more representative of the ECs actual performance, rather than basing them on single ratios, which, when considered alongside other ratios will lead to results that can be possibly misleading.

Keywords: Data Envelopment Analysis, Stochastic Frontier Analysis, Electricity

P-014

Technical efficiency and organisational change in UK public library systems: A Stochastic Distance Function approach.

Hammond, CJ

The provision of public library services in the United Kingdom is the responsibility of local authorities, each of which operates a multi-outlet library system, typically comprising a central library, often with both fixed and mobile branch libraries. The paper extends and develops previous analysis of the service technology and relative efficiency of UK Public Library systems using econometric cost functions (Hammond (1999)) and data envelopment analysis (Hammond (2002)). Following the reorganisation of the local authorities, beginning in 1995/6, the provision of library services in a subset of the areas was subject to structural change, which is well documented in the annual reports and statistical surveys conducted by each authority. This recent experience provides an outstanding opportunity to investigate the effect of organisational change and operational adaptation on technical efficiency. Using an extended panel data set spanning the period of transition, the magnitude and temporal evolution of relative technical efficiency scores are examined using econometric estimates derived by estimating a time varying, multi-output stochastic distance function.

Keywords: Public Library Efficiency

15.15 – 16.30

Stream A13 – Theory III

P-016

Introducing external factors in nonparametric frontier models: a unifying approach

Cinzia Daraio and Leopold Simar

The explanation of productivity differentials is very important to identify the economic conditions that create inefficiency and to improve managerial performance. In literature mainly three approaches have been developed: a one-stage approach, a two- stage approach and a bootstrap-based approach. Daraio and Simar (2003) propose a full nonparametric methodology based on conditional FDH and conditional order¡m frontiers. In this paper we propose a unifying approach to introduce external-environmental variables in nonparametric frontier models. Developing further the work done in Daraio and Simar (2003) we introduce a conditional DEA estimator, i.e., an estimator of production frontier of DEA type conditioned to some external-environmental variables which are neither inputs nor outputs under the control of the producer. A robust version of this convex conditional estimator is also proposed. Since Farrell's 1959 work, convexity has always been a crucial assumption on the production set structure.

In many empirical applications, however, as is the case for the mutual funds industry, the convexity assumption can be reasonable and sometimes natural. The paper, completing the tools available for practitioners, offers a whole set of efficiency measures useful to explain efficiency differentials in several different empirical contexts.

Keywords: convexity, external-environmental factors, production frontier, nonparametric estimation, robust estimation.

P-091

A constant sum of outputs DEA model for Olympic Games target setting

Villa, G. and Lozano, S.

In Lozano et al (2002) a VRS, AR-weighted constrained DEA model was presented for measuring the performance of nations at summer Olympic Games. Recently, Lins et al (2003) has proposed another DEA model called Zero Sum Gain (ZSG-DEA), which incorporates the fact that the total sum of medals that can be won by the participants is in principle constant. Unfortunately, their model is non linear, which makes it difficult to solve.
In this paper we propose a new DEA model called Constant Sum of Outputs (CSO-DEA), which takes into account such scenario with the advantage that the resulting model is a linear program. First, the efficiency of the units is assessed using the model in Lozano et al (2002) and then the CSO-DEA model is solved.
The CSO constraint makes it necessary to project all units jointly instead of independently. This leads to a centralised target setting approach that has the peculiarity that in order for the inefficient units to increase their outputs it must happen that the efficient units be allowed to decrease them. In order to properly manage these output increases and reductions, the ratio between the CSO radial output increase and the theoretical radial output increase obtained in Lozano et al (2002) is computed and balanced among the different participants. Thus, for example, all units may reach 80% of their theoretical targets, which means that inefficient units would increase their outputs but to a less demanding target level and mainly thanks to the fact that efficient units would devolve 20% of their outputs in order to allow for that increase. The sought balance is not perfect since the radial output expansion must be complemented with rectangular (i.e. additive) output increases. In any case, the described situation considered in the proposed approach, that for efficient units sets targets that are less demanding than the observed outputs, is rather unconventional in DEA but sound in this context.
We have applied the proposed model to the case of Sidney 2000 Olympic Games. We have compared the results with those in Lozano et al (2002) and Lins et al (2003) using the Spearman's Rank Correlation Coefficient with the conclusion that there are no statistical differences between the three rankings. The proposed CSO-DEA approach, however, is simpler than the non-linear ZSG-DEA approach and sets more realistic targets than Lozano et al (2002).

Keywords: Constant Sum of Outputs, Olympic Games

P-132

The super - efficiency procedure is for outlier identification, not for ranking efficient units

Rajiv D. Banker and Hsihui Chang

In this paper, we conduct simulation experiments to evaluate the performance of two alternative uses of the super-efficiency procedure in Data Envelopment Analysis (DEA). The first is for outlier identification (Banker, Das and Datar 1989) and the second is for ranking efficient units (Anderson and Peterson, 1993). We find that the ranking procedure does not perform satisfactorily. In fact, the correlations between the true efficiency and the estimated super-efficiency are negative for the subset of efficient observations, and the conventional DEA model performs as well as the super-efficiency DEA model when all observations are considered. However, when data are contaminated with outliers, the use of the super-efficiency model to identify and remove outliers results in more accurate efficiency estimates than those obtained from the conventional DEA estimation model.

Keywords: DEA, Super-efficiency, Outlier identification, Efficiency ranking, Simulation study.

Stream B13 – Malmquist I

P-038

Malmquist indexes of productivity change in Estonian banking

Kirikal L.

The problem of banking and financial system soundness has become more important in all countries over the last years. In the transition countries, the weakness of the banking system is the major factor of delaying expected economic growth. Rapid financial sector reforms and drastic restructuring has been characteristic for all Central and Eastern European transition countries. Banks and other financial institutions are a unique set of business firms whose assets and liabilities, regulatory restrictions, economic functions and operating make them an important subject of research. Banks' performance monitoring, analysis and control needs special analysis in respect to their operation, productivity and performance results from the viewpoint of different audiences, like owners, regulators, customers, and management themselves. It is evident that to study results of financial sector reform and restructuring, a profound performance analysis is needed.

In the current study I estimate productivity change in Estonian banking using the Malmquist productivity index, which is first used for productivity analysis of Estonian banks. The data used in this study covers the period from 1999 to 2002, during which there was the steady development of financial institutions and stabilization in banking market.

The present study shows that Estonian banks experienced an average of a 25,6% annual productivity growth rate during 1999-2002 due to technological progress. In comparison of 6 Estonian domestic banks over the four periods, it was surprising that newest bank in Estonia - Preatoni Bank has the highest productivity growth. Generally, all Estonian banks have increased productivity as a result of technological progress on this period.

Keywords: productivity, banks, Malmquist productivity index, catching-up effects, technical change

P-095

Malmquist indexes using a Geometric Distance Function (GDF). Application to a sample of Portuguese bank branches

Portela M C S andThanassoulis E

Traditional approaches to calculate total factor productivity change through Malmquist indexes rely on distance functions. In this paper we show that the use of distance functions as a means to calculate total factor productivity change may introduce some bias in the analysis, and therefore we propose a procedure that calculates total factor productivity change through observed values only. Our total factor productivity change
is then decomposed into efficiency change, technological change, and a residual effect. This decomposition makes use of a non-oriented measure in order to avoid problems associated with the traditional use of radial oriented measures, especially when variable returns to scale technologies are to be compared. The proposed approach is applied in this paper to a sample of Portuguese bank branches.

Keywords: Efficiency, Malmquist Index, Bank Branches

P-039

Egyptian banking in transition and liberalization parametric & non parametric Malmquist application

Fethi MD, Shaaban M, Weyman-Jones, TG

Renovation and modernization of the financial sector is being a vital necessity for any emerging economy to keep them on course with the challenges arising from globalisation. Egypt, as an emerging economy, has introduced a wide range of structural economic reforms to create a viable banking system in the past decade. Reforms, mainly aimed to decrease the role of state and increase the role of market forces in the operation of the financial system. This study aims to examine whether the modernization process had an effect on productivity growth over the period of 1997-2002 using a panel data of 20 Egyptian banks.
We use parametric distance function estimation with composed error terms and compare this with nonparametric DEA methods. These models generate Malmquist productivity indexes, which can be decomposed into technical change, efficiency change and scale change components.

Keywords: Parametric and nonparametric distance functions, productivity, transition banking.

Stream C13 – Applications III

P-020

Sectoral productivity trends across OECD industries

Rolf Fare, Shawna Grosskopf and Dimitri Margaritis

This paper analyses relative productivity trends in a panel of OECD industries and explores the role of policy and innovation activity on productivity performance. First, a shift share analysis is used to assess the contribution of individual sectors to overall productivity growth in output per worker for each country. The results show that the contributions of sectoral (industry) to aggregate productivity growth for all OECD countries is predominantly driven by pure within sector effects with very little contribution emerging from sectoral shifts (the "in-between" static or dynamic effects resulting from higher or above average productivity industries gaining employment shares or low productivity industries loosing shares). The notable difference is Ireland which shows relatively strong "in between" effects consistent with an effective process of economic restructuring. For most OECD countries the major contributors to aggregate productivity growth are the high tech manufacturing and tertiary sectors. DEA methods are used to measure relative efficiencies and multifactor (TFP) productivity for high and low technology groups of industries across different OECD countries. The TFP index is constructed using ratios of distance functions, which are functions of inputs and outputs. This methodology provides valuable insights in assessing productivity growth gaps across industries and countries and the role of economic reform to growth patterns as it permits a breakdown of labour productivity growth into technological change, efficiency change and capital accumulation components. By decomposing further technological change into an input biased and a (pure) magnitude component, the extent to which policy induces a change in input price and mix can be assessed. Additional information on the linkage between policy, innovation and growth is obtained by an econometric analysis of the relationship between TFP growth and a set of both economy-wide and industry-specific regulative indicators.

P-050

Innovative entrepreneurship as a factor of growth and productive efficiency in Bulacan cooperatives

Calara S, Cabanda E.

The paper examines 135 cooperative entrepreneurs in 45 Bulacan cooperatives in the Philippines. It analyses the contribution of cooperative entrepreneurs using Schumpeterian concept of an entrepreneur-an innovator (Schumpeter 1934, 1993:66, Roepke 1992:9). It explores innovation contributed by managers, board of directors and committee heads and members in cooperatives for the past six years. It categorizes innovation by using a modified Schumpeterian classification, evaluates its degree of success, identifies its origin, measures its impact on members and on the cooperative enterprise. It analyses the performance of 29 cooperatives classified as small, medium and large scale using growth rate and measures total factor productivity (TFP) through data envelopment analysis Malmquist Index using panel data from 1995 to 2002. Using DEA application model (Fare 1994:71), Coelli 1996:26-228) five outputs were used namely, net income or surplus, dividends, patronage refund, total revenue and total assets. Two inputs were used namely, number of members and amount of share capital. The use of Malmquist Index allows the decomposition of productivity growth into technical change (innovation) and technical efficiency change (catch-up). When applied to cooperatives, the study identifies the effect of innovation to the productivity of small, medium and large scale cooperatives. It points out which category of cooperatives are able to adapt to new technologies as well as new policies.

Findings show that out of 29 cooperatives, 23 (79 percent) have a TFP greater than 1, the highest index is 1.252, while the lowest is 1.002. All nine small scale cooperatives have been found efficient with TFP indexes greater than 1 and are above the frontier. Small cooperatives obtained a TFP Malmquist index of 1.086, where technical change is 1.066 and technical efficiency change is 1.018 for the period 1995 to 2002.
Generally, TFP of Bulacan cooperatives is 1.062 for the period 1995 to 2002. Empirical results show that productivity of Bulacan cooperatives is above the world frontier or best practice. The main source of productivity is technical change or innovation, contributed by innovative entrepreneurs. Technical efficiency change representing 'catching-up' is a factor which has to be improved to further increase TFP.

Keywords: innovative entrepreneurship, innovation, technical change, total factor productivity

P-058

Regulatory reform and productivity performance of the Malaysian mobile telecommunications industry

Mohamad, Noorihsan

This paper explores the productivity performance of the Malaysian mobile telecommunications industry in the pre and post-liberalization environment particularly with the passage of both Communications and Multimedia Act 1998 and the Malaysian Communications and Multimedia Act 1998. Productivity has been measured by the Malmquist index, using a Data Envelopment Analysis (DEA) technique. The Malmquist productivity measures are decomposed into two components: technological change and technical efficiency change index. The findings suggest that Total Factor Productivity (TFP) has increased significantly for the whole industry, predominantly in the post-liberalization period through the establishment of Malaysian Communications and Multimedia Commission. Despite the positive productivity development that has taken place, the paper however found that technical progress has been the most important source of productivity growth to Malaysian mobile telecommunications industry. Low technical efficiency in the industry indicates a great potential for the industry to further increase its productivity through higher utilization of technology as well as technological knowledge dispersion. Continuously expanding market liberalization and enhancing the productive capacity of technology appears to offer better prospects for Malaysian mobile telecommunications industry to achieve greater productivity growth.

Keywords: Telecommunications, Liberalization, Malmquist Index, Malaysia

Stream D13 – Education II

P-044

Revealing the true story behind statistical information: a Data Envelopment Approach (DEA) to analyse Austria's universities' research performance

Leitner KH, Schaffhauser-Linzatti MM, Stowasser R, Wagner K.

The newly implemented Austrian Universities Act enforces universities to implement an Intellectual Capital Report which will be further determined by a ministerial regulation. By analysing former statistical information, it is possible to reveal indices that are suitable to internally and externally control universities for efficiency, hereby providing support to political decision-makers to structure the new reporting tool. Choosing the full sample of technical departments at Austrian universities as decision-making units (DMUs), we first used various correlation methods and factor analyses to reduce the total number of 48 indices to two input variables, staff and square meters, and various output variables such as third party funds, monographs, papers in refereed journals, research reports, scientific contributions, patents/licenses, students' evaluations, diploma and PhD theses. We then applied various DEA models to check the results for sensitivity, to rank the DMUs, and to reveal how the DMUs might improve their efficiency and to calculate their target values. These results were based on data from 2000 to 2002. The results of the DEA are confirmed by an empirical survey.

Keywords: Austria, DEA, university efficiency, performance evaluation

P-085

The determinants of college efficiency in French Canada: A Data Envelopment Analysis approach

Frederic Broussau, Pierre Ouellette and Valerie Vierstraete

In the Province of Quebec (Canada), the education system is characterized by an intermediate level between high school and university called College (CEGEP) that cannot be compared to colleges outside Quebec. This level is made up of two different types of grades. The first is dedicated to pre-university diplomas that lead to the university. Usually, it takes two years to complete this grade. These pre-U diplomas are made up of students that would complete an additional year in high school as well as an additional year at the university in regions such as the other Canadian provinces and in the United States. The second type of programs usually last three years and lead to jobs in the professional sectors such as welding, woodworking, and business techniques.

Colleges are different from school boards and universities in Canada as they depend more heavily on the government for their financing since college students only pay a small fee and Colleges do not have the right to tax as the high schools do. In fact, more than 85 % of their budget comes from the provincial government. Colleges' budgets are based on the number of students and the square meters of buildings and grounds. In 2000/01, the global budget of colleges amounted to 1,4 billion dollars.

The colleges' dependence to provincial financing has been particularly damaging in the 1990s when the government decided to reduce its deficit by mean of a reduction in its expenditures, including education expenditures. Universities and School Boards had the possibility to increase their revenues by increasing tuition fees and school taxes, but Colleges did not have such tools to compensate for lost revenues. In order to assess how colleges responded to budget cuts, we use the Data Envelopment Analysis method. This method enables us to

evaluate whether colleges produce on their production frontier and minimise theirs costs. We find that colleges improved their efficiency as a mean to attenuate the impact of budget cuts.

Keywords: efficiency, colleges

P-028

The use of multi-stage models to incorporate non-discretionary inputs in a DEA analysis of educational centers

Cordero Ferrera, J.M., Pedraja Chaparro, F. and Salinas Jiménez, J.

The aim of this paper is to study the responsiveness of efficiency indices (estimated for different educational centres) to the options in the literature regarding the inclusion of exogenous factors in this analysis. To be precise, we will concentrate on two crucial issues. In light of the extensive information on these variables derived from surveys, and in order to sum it up, we will first consider the possibility of either including the most relevant variables in the efficiency analysis or using Principal Components Analysis to summarise information contained in such variables. We will then compare alternative multi-stage approaches according to which such factors must be taken into account to calculate the final efficiency indices using regression and stochastic frontier analysis. The analysis covers 85 public educational centres in the region of Extremadura (Spain) for the 2001-02 school year.
In much of the empirical literature, when analysing the efficiency of educational centres analysts decide to use the traditional Banker and Morey Model (1986). Nevertheless, this method presents some methodological problems that can be avoided if multi-stage models are used, such as Fried et. al (1996, 1999, 2002). This paper shows, through an empirical application, that results may differ according to the approach chosen.

Keywords: Efficiency in education

Stream E13 – Methodology

P-051

Improving discrimination in Data Envelopment Analysis: PCA-DEA versus Variable Reduction. Which method at what cost?

Adler N and Yazhemsky E

In the data envelopment analysis context, problems related to discrimination often arise, particularly if there are a relatively large number of variables as compared to decision-making units. This paper presents a comparison of two discrimination-improving methods published in the literature that do not require additional preferential information; principal component analysis - based DEA (PCA-DEA) and variable reduction based on partial covariance (VR). Using a simulation based approach, a 10,000 observation dataset was computed, and the true weighted sum of slacks was compared to the results of the PCA-DEA and VR models. Performance criteria were based on the percentage of observations incorrectly classified; efficient DMUs defined as inefficient and inefficient DMUs defined as efficient. According to the simulation results, a trade-off was observed, with both methods

improving discrimination by reducing the probability of the latter error (which proved very large, especially under variable returns-to-scale DEA models) but increasing the probability of the former error. The comparison of the two methodologies carried out in the study showed that PCA-DEA provides a more powerful discrimination tool than VR with consistently more accurate results. Guidelines for the PCA-DEA user are presented based on the concept of an "optimal index" that aims to minimize both types of error. The optimal index is the percentage of retained information providing the closest proximity to the true weighted sum of slacks. It would appear that the optimal index for the constant returns-to-scale (variable returns-to-scale) model ought to be equal to 80 (76)%.

Keywords: Data envelopment analysis, principal component analysis, discrimination, covariance, simulation

P-088

Problems with the Variable Returns to Scale model in DEA and Dynamic Clustering as a possible solution

Gautam Appa and Carlos Bana e Costa

We outline some serious philosophical, technical and practical problems with the Variable Returns to Scale model of Data Envelopment Analysis. Several of these are illustrated with some recent experiences in applying the model. Dynamic Clustering, a way of choosing the same scale comparators for each DMU, is suggested as a possible solution.

P-195

A review of methods of comparing programmatic efficiency between two or more groups of DMUs in Data Envelopment Analysis.

Gary Simpson and Bhavesh Dayal

In some applications of Data Envelopment Analysis (DEA) there is some doubt as to whether all the DMUs form a single group with a common efficiency distribution. The Mann-Whitney rank statistic has been used to evaluate the statistical significance of two groups of DMUs coming from a common efficiency distribution and to test if the two groups have a common frontier. These procedures have subsequently been extended using the Kruskal and Wallis rank statistic to consider more than two groups. This paper identifies problems with the second of these applications and considers possible alternative methods of testing if groups have a common frontier, and the difficulties of disaggregating managerial and programmatic efficiency within a non-parametric framework.

Keywords: Data Envelopment Analysis (DEA); Statistics, Programmatic Efficiency.

16.45 – 18.00

Stream A14 – Theory IV

P-176

Fitting smooth slack-free frontiers using maximum correlation modelling

Chris Tofallis

The fact that DEA frontiers do not extend all the way to the axes means that such frontiers are incomplete. Therefore many inefficient units will not be naturally enveloped. This implies that the radial DEA score for such units will not take account of the additional improvements which appear in the non-radial slacks. We present a way of fitting a smooth frontier to the strictly efficient units. This smooth frontier extends to the axes, enabling all inefficient units to be assessed radially. The fitting method is known as *maximum correlation modelling*, and *unlike* multiple regression, it allows both multiple inputs and multiple outputs to be included in a single equation frontier model. It can incorporate any theoretical requirements on the functional form of the frontier.

P-019

Economies of scope in financial services: A DEA bootstrapping analysis of the US insurance industry

Cummins, J.D., Weiss, M.A., Zi, H.

This paper investigates economies of scope in the U.S. insurance industry utilizing data envelopment analysis (DEA). We test the conglomeration hypothesis, which holds that operating a diversity of business can add value by exploiting cost and revenue scope economies, versus the strategic focus hypothesis, which holds that firms can best add value by focusing on core businesses. We analyze whether it is advantageous for firms to offer both life-health and property-liability insurance or to specialize in only one major industry segment. We test for economies of scope by estimating DEA technical, cost, and revenue efficiency. We innovate by estimating cross-frontier efficiency, where each group of firms (diversified firms and specialists) is compared to a reference set consisting of the other type of firm, and also estimate pooled and own-group frontiers. We use the smoothed bootstrap procedure to obtain standard errors of the efficiency scores and correct biases. The corrections for bias are fairly substantial, ranging from 5 to 10 percentage points. Although diversified firms dominate specialists in the production of diversified firm output vectors in terms of revenue efficiency, specialist firms dominate diversified firms for the production of specialist output vectors in revenue efficiency and also dominate diversified firms in cost efficiency for property-liability output vectors. Thus, overall, the results suggest that strategic focus appears to be a better strategy than conglomeration.

Keywords: economies of scope, bootstrapping, cross-frontier analysis

P-131

Evaluating contextual variables affecting productivity using Data Envelopment Analysis

Rajiv D. Banker and Ram Natarajan

A DEA-based stochastic estimation framework is presented in this study to evaluate contextual variables affecting productivity. Appropriate estimation methods and statistical tests are considered under a variety of data generating processes (DGPs). Conditions are identified under which a two-stage procedure consisting of DEA followed by regression analysis yields consistent estimators of the impact of contextual variables. Conditions are also identified under which a DEA model of input and output variables, followed by another DEA model of first stage inefficiency scores and contextual variables is appropriate. The application of the various procedures is illustrated by analyzing input, output and contextual variables data for 964 school districts in Texas during 1997-98. Results underscore the importance of evaluating robustness of results to different assumptions maintained about the DGP.

Keywords: Data envelopment analysis, Data generating process, Contextual variables, Two-stage approach, Texas school districts

Stream B14 – Industry

P-047

From Data Envelopment Analysis technique to the development of a productivity system

Alirezaee MR, Mirhassani SA.

Data Envelopment Analysis (DEA) as a non-parametric technique has been used for measuring the efficiency of Decision Making Units (DMUs) in quite a numerous number of studies. This paper focuses mainly on the requirements of developing a productivity system based on the DEA technique. The efficiency and effectiveness as the main components of productivity can be well defined if the levels of the organization are distinguished properly and the indices, which are the summary of the organization indicators, are regarded as inputs /outputs for each set of DMUs. The necessary tools and applications will be discussed throughout the paper. A productivity system designed for the 25 gas distribution firms of the National Iranian Gas Company (NIGC) will be presented next.

Keywords: Data Envelopment Analysis, Productivity System, Indices, Gas Distribution, National Iranian Gas Company

P-004

Well Drilling performance measurement using Data Envelopment Analysis

S.A. MirHassani, M.R. Alirezaee

This paper provides an examination of the applicability of Data Envelopment Analysis (DEA) to support efficiency measurement of well drilling operations from managerial point of view which has been done for National Iranian Oil Company (NIOC). The study focuses on three types of indices: well drilling program, the cost, and the time. Data and result for 35 drilled wells with their geological specifications is given.

Keywords: Data Envelopment Analysis, Well drilling, Oil and Gas industry

P-034

Efficiency in Indian manufacturing sector - an Inter-State analysis

Kuldip Kaur and R.S. Bawa

Industrial development of an economy is the result of the interaction of two main forces (i) investment in capacities and (ii) efficiency with which these capacities are exploited. Building up of a productive capacity depends upon the savings and hence investments and reinvestments in a particular economy. While finding reason for the low industrial growth of the Indian economy, low saving rate can't be the culprit, since there had been substantial growth of saving rate since independence. Hence the inefficiencies in the exploitation of the resources and inputs can be blamed for low industrial growth of India. For a country like India, with a multiplicity of socio-economic demands on its resources, efficient utilization of such limited resources, assumes fundamental importance. Furthermore, LPG (Liberalization, Privatization and Globalization) policies started in early 1980's and strengthened in 1990's, opened the Indian manufacturing sector for greater competition with in as well as outside India. It is expected that Indian industries will have to achieve greater efficiency and competitive strength. Hence, in a dynamic context, an approach where focus is on output growth rates rather than on the efficiency in generating such output, ignores the basic concept that resources and inputs have opportunity costs. If they do not yield a minimum return as a result of good utilization, they are better utilized elsewhere. So the efficiency in resource and input utilization has to be given a center stage role in policy formulation since the extent of resource utilization is the critical determinant of economic efficiency.

It is against this background that the study aims at calculating and comparing the efficiency for the manufacturing sector of 18 major states of India. Here the decision making units are states since the study aims at evaluating the efficiency of the working of the state industrial policies and policies at the national level,. The main analysis applied for calculating the state level efficiency and slacks in the utilization of main inputs is Data Envelopment Analysis (DEA). The study is based on cross-sectional data collected from Annual Survey of Industries (ASI) reports for three points of time i.e. 1980-81,1990-91 and 2000-01. These reports present the data for organized manufacturing sector of India as well as for states. Four inputs and one output has been used. The inputs used are rupee values of fixed and working capital, actual number of administrative and support staff employed. The output variable is gross output expressed in rupee terms. Analysis has been undertaken at three different points of time to record the impact of LPG policies on the efficiency of manufacturing sector of major states of India. Here 1980's have been considered as the mild liberalization phase,1990's as the liberalization phase and the year 2000-01 as the post liberalization year.

The study has been divided into three sections. First section deals with the introduction to the study. Second discusses the data base and methodology and the third highlights major findings of the study and draws some conclusions and policy implications of the study.

Keywords: Manufacturing sector efficiency

Stream C14 – Applications IV

P-042

On the usefulness of DEA for strategy development: A tourism destination case study

Matthias Fuchs and Florian Zach

In accordance to the resource-based view competitive advantages stem from the ownership of resources which allow performances better and/or cheaper than that of competitors (Hall 1992; Collis/Montgomery 1995). In addition, firms can be seen as bundles of interrelated economic activities, which require different resources to perform. Thus, the market-based view assumes that the configuration of economic activities with respect to attractive (i.e. profitable) market positions is the main source of competitive advantages (Porter 1985; Løwendahl/Revang 1997). However, in both cases the 'strategic' value of resources may only be evaluated by including the customer's view (e.g. customer satisfaction). Hence, strategy literature recommends the quality management tool of benchmarking to derive at this relevant information (Zairi 1992; Watson 1993; Boos/Jamari 1994; Czarnezki 1999; Börner 1999; Tucher 2000). Nevertheless, benchmarking projects often fail to support strategy development because they are neither able to integrate resource and market specific data, nor are they able to consider the performance of processes comprehensively (Cox et al. 1997). In addition, benchmarking results usually are purely 'descriptive', so that there remains a large interpretative freedom for strategic decision makers (Madu/Kuei 2001). Finally, traditional benchmarking is based on comparisons with 'average' performance figures and/or rather unreachable 'superlatives' (i.e. best-practices) leading to undesired tendencies of imitative process adaptations (XX 2004). The aim of the paper is therefore to move forward Data Envelopment Analysis (DEA) as a valuable benchmarking approach to cope with the above mentioned problems of strategy formulation (Hawdon/Hodson 1996; Homburg 2000; Ross/Droge 2002). It will be shown that DEA is not only able to take into consideration typical customer-driven measures of performance, but may also include customer generated resource information. To derive at the latter data, the model of factor-structure of customer satisfaction (CS) will be employed (Kano 1984; Silvestro/Johnston 1990; Matzler/Sauerwein 2002; XX/XX 2004). It groups resources into three different qualitative categories of drivers for customer satisfaction: Basic factors define minimum requirements and cause dissatisfaction if not fulfilled but don't lead to CS if fulfilled or exceeded. Performance factors lead to CS if performance is high and lead to dissatisfaction if performance is low. Finally excitement factors increase CS if delivered but do not cause dissatisfaction if they are not delivered. The paper is testing the new approach within the alpine tourism industry (XX 2004). A total of 68 tourism organisations perform as DMUs as being responsible for the strategic decision making in geographically well defined tourism destination areas. Next to typical quantitative destination output measures (e.g. tourism sales) and input data (i.e. tourism capacities, promotional efforts, etc.) additional qualitative data come from a guest survey comprising 16.000 questionnaires. At the output side of the DEA indicator the satisfaction with 7 destination value chain areas (e.g. accommodation, sports, entertainment, etc.) performs as customer-driven performance measure. Uncontrolled input variables allow the inclusion of additional qualitative resource information as for each value chain area it will be possible to determine whether tourists perceive it as basic, performance or excitement

factor. Hence, comparability of destinations will be optimized as best-in class (i.e. reference) units also show the most similar resource configuration in the eyes of the tourists (Wöber 2002). Finally, DEA's decision model character makes it possible to derive at well-grounded improvement strategies. Thus, the conclusion section not only discusses the empirical DEA results but also reflects the various opportunities of the presented newly benchmarking approach for strategy formulation.

Keywords: strategic management, strategy development, uncontrolled input, quality benchmarking, tourism case study

P-092

Service-Quality in the Brazilian mobile telephony: an efficiency-frontier analysis

Resende, M., Tupper, H.C.

The mobile telephony sector is characterised by the dynamic interplay of rapid changes in technology and an apparently growing competition as indicated by the fierce non-price competition and yet the entry of new operators in some cases. In that context, a relevant and neglected issue is to assess how service-quality responds to an increasingly competitive environment. This study uses Data Envelopment Analysis (DEA) to assess the quality-efficiency of mobile operators in Brazil during the 2000-2003 period. Windows analyses were conducted for different window's width, taking as reference eight quality indicators pertaining distinct forms of complaints and calls completed and interrupted. The paper advanced an interpretation of the indicators reflecting a positive dimension of quality as outputs and those reflecting negative aspects of quality as inputs. This adaptation allowed to generate efficiency frontiers for service-quality in the mobile sector. Given potential heterogeneities across firms that relate to the frequency band and to the technology (TDMA, CDMA among others), the paper considered adjusted efficiency scores. The Tobit model for censored data was estimated to control for the aforementioned aspects. Rescaled residuals from the econometric estimation produced efficiency scores for service-quality. The evidence indicated, in general, a steadily improvement of efficiency over time. Nonparametric tests indicated that significant shifts in the frontier occurred over time even for shorter sub-periods.

Keywords: Efficiency, service-quality, Data Envelopment Analysis, Tobit model, mobile telephony

P-174

The longitudinal and comparative performance effects of privatisation and regulation in the English and Welsh water and sewerage industry: 1985-2000

David Parker, David S. Saal, and Tom Weyman-Jones

After its privatisation in 1989, the water and sewerage industry of England and Wales faced a new RPI + K regulatory price cap, a system which is a variant of the typical RPI-X regulation system. The system was designed to both encourage increased efficiency and also provide

funding for the substantial capital investments which were necessitated by the tightening of environmental and drinking water standards after privatisation. Consideration of the RPI+K regime suggests the possibility that the "relaxation" of RPI-X regulation, in order to allow for the industry's massive capital requirements, may have dulled the efficiency incentives normally associated with price cap regulation. Given this hypothesis, this paper will use stochastic frontier techniques to estimate a Malmquist index of productivity growth as well as indices of technical efficiency and technological change for the period 1985-2000. These indices should allow a more careful consideration of how and whether privatisation and the RPI+K system affected productivity growth in the industry.

Keywords: Malmquist index, water and sewerage industry, distance functions

Stream D14 – Agriculture I

P-033

Productivity convergence and rice acreage control programmes in Japan

Yamamoto Y, Kondo K, Sasaki J.

In Japan, rice has strongly been protected. And its domestic prices have been supported higher than international prices. These had consequently accumulated surplus rice in the previous decades. Thus, in 1971 Rice Acreage Control Programmes have been introduced. The programmes have been posting a heavy burden on government budgets. Under such conditions, the government of Japan has been reluctant to enhance research and development geared towards increasing rice productivity. This policy stance of Japan represents a serious impediment to the advancement of the rice technology frontier in Asia (Hayami 2001).
This paper measures total factor productivity (TFP) of rice farms, in 43 prefectures of Japan over the period from 1971 to 1995. Convergence in TFP across the prefectures is also tested. We first calculate the input-oriented Malmquist TFP indices using non-parametric DEA approach. Having measured TFP for these prefectures both conventional cross-section tests for Beta and Sigma convergence (Bernard and Jones 1996) and panel unit root tests for convergence (Levin and Lin 1992) are performed. A balanced panel of 43 prefectures is used in our estimation.
DEA results show that the average annual change in TFP is 0.54%, where the major contributing factor is technical progress. The regional results suggest that 27 out of 43 prefectures have positive TFP growth between 1971 and 1995. Sixteen prefectures have less than one per cent positive growth, eight have between one and two per cent growth and only three prefectures have growth of more than two per cent per annum. The highest productivity growth is found in Hokkaido Prefecture.
To test for Beta convergence, the productivity growth rate of each prefecture in the cross section is regressed on its own initial TFP level. The regression results show that the estimated parameter, which is the coefficient of the initial productivity level, is negative and significant, implying that there is Beta convergence in TFP across the
prefectures. The second test Sigma convergence, which considers the behavior of the cross-sectional standard deviations of the log of TFP level over the time period, cannot be supported. The dispersion of TFP levels is found to have increased throughout the sample period.

The third test is based on time-series econometrics approach, which follows Bernard and Jones (1996) in applying panel unit root tests (Levin and Lin 1992). The more sophisticated time-series panel unit root tests provide evidence of convergence in TFP.
One possible explanation for the lack of convergence in Sigma test is that TFP levels in some prefectures seem to be more sensitive to unfavorable weather conditions, and therefore an increase in dispersion of TFP levels during the sample period is found.
The results show that rice productivity in Japan has stagnated and converged not only due to slowdown in technical progress but also due to exhaustion in catching-up with technology frontier since introduction of Rice Acreage Control Programmes.

Keywords: Malmquist TFP indices, Convergence, Panel unit root tests, Rice Acreage Control Programmes, Japan

P-081

Technical efficiency of trout farms in black sea region, Turkey

Cinemre, H.A., Ceyhan,V., Bozoglu, M., Demiryurek, K. Kilic, O.

The purpose of this research are to measure technical efficiency of sample farms and to explore determinants of technical efficieny in Black sea Region. Data Envelopment Analysis was used to measure technical efficiency of farms. The results suggest that average output of farms in the region could have been increased to 17% under prevailing technology. The technical efficiency of the sample trout farms in the research area is ranged from 0.49 to 1 and is, on average, 0.83 and positive size-efficiency has been found. Research results also reveal that there are negative relationship between technical efficiency and rearing area (m3), feed intensity. However, labour has positive effect on technical efficiency in large farms. On the other hand, scale efficiency results indicate that 51% of the total farm has increasing return to scale while that of decreasing return to scale is 45%.

Keywords: Technical efficiency, DEA, trout farms

P-126

Evaluation of technology introduction in a beef cattle production system in Pantanal wetlands. Analysis of efficiency.

Abreu UGP de, Baptista AJM dos S, Paulo Sávio Lopes PS, Torres R de A, Santos H do N.

In a production system two types of efficiency can be identified: technical and economical. The technical efficiency is linked with the physical aspects of production, and the economical efficiency with the economical aspects. The link for a system to be economically efficiency it should have maximum technical efficiency. The data envelopment analysis (DEA) was used to analyze the efficiency of the production system. During eight years (1995 to 2002) technologies were adopted in a ranch. Ten inputs and one output were used to evaluate the production system efficiency. The principal component analysis was utilized to determine the most important inputs ("mineral salt/ vaccine/ medication", "workforce and social security" and "investment") with significant correlation ($p<0.01$), with the three first components that explained 91.6% of the total variation. The efficiency calculated with DEA for 1995, 1996, 1997, 1998, 1999, 2000, 2001 and 2002 were for constant returns to the scale (CCR) 0,8290, 0,6574, 1, 0,5390, 0,7990, 0,8010, 1 and 0,9291; and for variable returns to

scale (BCC) 0.8841, 0.7460, 1, 0.6350, 0.8530, 0.9342, 1 and 1, respectively. The years 1997 and 2001 were considered as of maximum technical efficiency. The inefficient years were due to the increasing returns to scale or the decreasing returns to scale. Therefore, the rancher did not invest efficiently. The input "investment" should be more adjusted to the other inputs.

Keywords: beef cattle, production system, Data Envelopment Analysis (DEA), efficiency.

Stream E14 – Malmquist II

P-013

Measuring Productivity Change (PTF) in the Peruvian electricity sector

Beatriz Tovar de la Fé, Lourdes Trujillo, Raul Pérez Reyes-Espejo

In Peru, as in most countries, the electric system was managed in a centralized way by a network of public firms. In 90's Peru began structural market oriented reforms, through la Ley de Concesiones Eléctricas de 1993 the Government divest the industry in three activities: generation, transmission and distribution. Generation was considered to be a competitive activity (unbundling of firms and price deregulated). Peru wants competition between its generation firms as a way of improving their competitiveness, reliability and quality. Since 1994 several state owned enterprises were privatized, particularly in generation. The purpose of the paper is to analyze the productivity operators evolution of electricity generation firms in Peru, in order to know if the reforms have improved the efficiency in generation and to identify potential sources of productivity changes, based on the restructuring of electricity sector: property changes and changes in market structure. The paper provides a systematic analysis of productivity changes decomposition into technical efficiency and technological change of electrical generation restructuring in Peru. The analysis is based on a non-parametric approach. We estimate productivity change using the Malmquist Index which has been developed within the non-parametric (DEA) framework by Farë et al. (1994). This index does not require input price nor behaviour assumption and it could be decompose into the catching-up effect (technical efficiency) and the frontier shift effect (technical change).
The available data cover 4 years (1999-2002) and 14 generation firms. This provides a panel of data large enough to allow an assessment of the evolution of the relative performance of these firms.

Keywords: Malmquist Index, electrical generation efficiency

P-197

Efficiency and convergence in developing countries

Camilla Mastromarco

Following Temple, who states that "a better understanding of what generates economic growth could make a huge contribution to human welfare" (Temple 1999, p.112), this study addresses the determinants of the catching-up effect toward the frontier (efficiency), viz. the forces that drive the growth of developing countries.

Productivity growth is viewed as having three components: technological change, technological catch-up and a scale factor. Using a stochastic frontier model these components are calculated for 57 developing countries over the period 1960–1990. The empirical analyses follows three stages. The first stage tests for the statistical significance of the different hypotheses regarding augmenting factors and neutral technology (Hicks, 1932, Harrod, 1942 and Solow,1969 neutrality). Technology is found to be non-neutral. Moreover, the specification of the production frontier with human capital affecting the quality of labour force fits the data better. Human capital affects total factor productivity through different channels (efficiency and augmenting labour force). In the second stage, the evolution of the entire distribution of the productivity components is analysed. It turns out that the main source of convergence is efficiency and innovation. In the final stage of the empirical analysis, the channels through which trade affects the components of output growth are analysed. The focus is on foreign direct investment, imports of machinery, import discipline, and export of manufacturing goods. All these channels have a positive effect on efficiency. The result is consistent with the predictions of endogenous growth models with trade (Grossman and Helpman 1991 and Rivera-Batiz, Romer 1991, Young 1991 and Barro and Sala-i-Martin 1995).

P-096

Inefficiency, technical progress and productivity change in German banking: A category-based empirical study

Li, C.-F.

This paper examines the pattern and source of productivity change based on panel data consisting of 13 categories of German banks in the decade from 1992 to 2001. Our DEA-based study shows that the vast majority of banking groups presented low efficiency in each year of the sample period. Furthermore, with a Malmquist-index approach, we find that on average all categories of banks experienced technology progress through the entire period, but more than half of them also suffered technical efficiency declines. In general, the productivity growth was attributable to technology advance rather than efficiency improvement, while the productivity decline was ascribable to efficiency decrease primarily resulting from scale effect. Moreover, the results indicate that foreign banks' productivity growth was the highest in the sample due to rapid improvement in technology, efficiency and scale simultaneously. By contrast, the most rapid productivity regress occurred within private bankers, all of which was mainly due to a steep decline in scale efficiency.

Keywords: Banking, Efficiency, Productivity, DEA, Malmquist index

Monday 6th September 2004: 11.15 – 12.30

Stream A21 – Theory V

P-090

Calculation of scale elasticities in DEA models by numerical methods

Finn R Førsund, Lennart Hjalmarsson, Vladimir Krivonozhko

Returns to scale is a very useful indicator characterising the market forms of competing firms within a sector. Information on this parameter may be used by regulators in promoting competition and improving productivity and efficiency. In DEA the qualitative characterisation of returns to scale has occupied many researchers since the seminal paper by Banker, Charnes and Cooper (1984). However, public policy purposes seem to be better served by numerical information, e.g. how important is the deviation from the competitive market condition that the scale elasticity must be equal or less than one? By the method of Førsund and Hjalmarsson (2004) using the efficiency score and shadow value on the convexity constraint the numerical value of the scale elasticity for radial projections of inefficient points to the frontier can be calculated (provided they are interior points). To calculated other scale elasticity values synthetic observations have to be introduced. This approach is not so convenient if the purpose of investigating scale properties is to get an overall picture of the scale properties not necessarily limited to actual observations or their projections.
The purpose of the paper is to provide a more powerful and general method that can be used to numerically evaluate the scale elasticity at any point on the DEA surface, using the approach developed in Krivonozhko et al, 2002. The approach is based on cutting through the general multidimensional faceted DEA frontier with a two-dimensional plane in any direction from the origin, and calculating the scale elasticities for any point along the intersection of the planes and the frontier. For vertices or points on edges between facets the numerical method gives the scale elasticity based on a right-hand or left-hand derivative in a proportional direction from the origin, corresponding to the basic definition of scale elasticity, whereas the previous approach only gives an upper and lower limit on the value.
Empirical examples are provided.

P-075

On the anatomy of productivity growth: A decomposition of the Fisher Ideal TFP index

Kuosmanen T, Sipilainen T

Development of sophisticated methods for measuring total factor productivity (TFP) enables us to distinguish sources of productivity changes. As a consequence, many recent studies interpret productivity in broader terms as a welfare measure, which includes the effect of technical change among other components. Decomposing the overall productivity index into sub-components contribute to our understanding of what drives the observed productivity measures by providing a more detailed picture of their constituents. Decompositions of productivity date back at least to the seminal work of Farrell. The decomposability of the Malmquist index is generally seen as its main advantage to other productivity indices, together with its weaker data requirements. However, the classic productivity indices such as the Fisher ideal TFP index and the Törnqvist TFP index currently lack such a decomposition.
This paper intends to fill this gap at least partly by proposing an intuitive decomposition for the Fisher ideal total factor productivity index. We express the Fisher index as a product of five components: changes in technical efficiency, allocative efficiency, scale efficiency, technological possibilities, and the input-output mix. These five components further decompose into separate sub-components for inputs and outputs, offering a detailed picture of the constituents of productivity change as measured by the Fisher index.
Our decomposition contributes to the productivity literature in several important ways. Firstly, the decomposition further enhances our general understanding about how the Fisher

index works; which effects it captures, which effects not. For example, we will see that changes in allocative efficiency contribute to the Fisher index, but not to the Malmquist index. While a number of decompositions of the Fisher ideal price and quantity indices have been proposed, we are unaware of other decompositions in the present context of productivity indices. Secondly, the decomposition provides a more detailed picture about the driving forces behind productivity growth (or decline) in empirical applications. In the application on 459 Finnish farms for 1992 - 2001 we will find which factors explain the observed productivity changes in the Finnish agriculture during the time period, which covers the Finnish EU accession in 1995. Thirdly, better understanding of the anatomy of the Fisher index also enables one to tailor the productivity index for the purposes of the study. If some component(s) captures effects that do not fit in a given definition of productivity, the decomposition enables one to correct for (or eliminate) these undesirable components from the overall productivity index.

Keywords: Fisher index, technical efficiency, allocative efficiency, scale efficiency, technological possibilities, input-output mix

P-093

A protocol for converting production trade-offs to weight restrictions

Victor V. Podinovski

In this paper we show how the specification of production trade-offs between the inputs and outputs can improve the discrimination of DEA models. Since existing DEA software would not allow for the incorporation of trade-offs, a way around this problem is in using equivalent weight restrictions. Simple formulae for translation of trade-offs to weight restrictions are presented and illustrated by examples. If the trade-offs or equivalent weight restrictions are used, the radial targets of inefficient units are always producible, which contrasts with the other methods used to assess weight restrictions.

Keywords: data envelopment analysis, weight restrictions, trade-offs

Stream B21 – Theory VI

P-076

Does model misspecification in DEA affect some DMUs more than others?

Experimental evidence from a CRS frontier

Galagedera, D.U.A.

In this paper, using a simulation study, we investigated the effect of relevant input variable omission, irrelevant input variable addition and incorrect returns to scale assumption in a CRS output orientation DEA model on technical efficiency of individual production units. In previous studies of this type, the discussion is confined to the effect on overall performance. Instead, we sorted the DMUs into five sets according to their true efficiency and examined the effect of model misspecification on the DMUs in each set separately. This enabled understanding of DEA model misspecification effects at different levels of efficiency which has previous been overlooked.

The results show that the effect of model misspecification via input variable omission/ addition on DEA efficiency in high and low efficiency DMUs is similar to the effects observed in overall efficiency. When returns-to-scale is misspecified as VRS, the effect of variable omission (addition) in high and low efficiency DMUs is the same as with CRS except at a smaller (larger) scale. Absolute deviation between DEA and true efficiency reveal that the adverse effect of variable omission is the largest in high efficiency DMUs and this adverse effect eases with decreasing DMU efficiency. On the other hand, the adverse effect of irrelevant input variable addition is the largest in low efficiency DMUs and this adverse effect eases with increasing DMU efficiency. High efficiency DMUs appear to be the worst affected in DEA ranking. The effect of variable omission on virtual input does not seem to be associated with DMU efficiency level. When the correlation between input variables is low the size of the omitted variable can adversely affect DEA efficiency.

Keywords: Model misspecification, Experimental evidence, technical efficiency

P-097

Ranking of DEA units with an set of weights to performance indices

Liu Fuh-Hwa F. and Ling-Chuan Tsai-

In this paper we propose a three-phase procedure to rank a set of units that are assessed in several to-be-minimized and to-be-maximized indices. In phase-one, the slacks-based measure of super-efficiency model introduced by Tone (2002) is employed to obtain the projection points of the efficient unit on the foremost frontier. Substitute the efficient unit by their projection points obtained in phase-one to form a new set of units. In phase-two, the slacks-based measure model introduced by Tone (2001) is employed to assess the units in the new set. The efficient units and the projection point of each inefficient unit on the secondary efficient frontier are obtained. A linear programming model is used in phase-three to determine the set of weight of the indices for the projection points and units on the secondary efficient frontier. Use the set of common weight for indices, the efficiency score of each point on the secondary frontier is computed. The absolute efficiency score of an efficient unit in phase-one is equal to the multiplication of the score of phase-three and its super-efficiency. The multiplication of the efficiency score in phase-two and the efficiency score in phase-three is the absolute efficiency score of the inefficient unit. Units are ranked according to their absolute scores.

P-116

A simulation-based adaptive policy framework to study the effects of policy cycles on the efficiency frontier dynamic

SClaudina Vargas

This work conceptualizes a tool that integrates data envelopment analysis (DEA), Malmquist productivity indices (MPI), and process learning (PL) in a discrete-dynamic stochastic simulation framework to provide flexibility for studying the dynamics of the efficiency frontier as it responds to asynchronous policies, which are based upon variations in production efficiency as determined by DEA and the process quality. We model a class of decision-making problems under uncertainty where there are K decision making units (DMUs) with similar production operations which act independently of each other to control

production quality and efficiency, but whose actions have global effects. The DMU makes decisions based on the state of nature, which is determined, at any period, by the productivity score - measured by DEA/MPI - and the process quality - measured by the desirability functions. The decisions, however, are limited by management, the current policy's state, and other constraints. Thus, policy decision plans are adaptive and policy cycles differ across the DMUs. The Policy cycle is the average time interval between sequential policy decisions; it is a measure of the responsiveness of a DMU to changes in its state and reflects managerial strategy. The policy cycle depends on the effects of the policy, which are dynamic due to process learning conditions, and imprecision. Hence, for any DMU the transition to a target state is uncertain.

We employ simulation to model the dynamic behavior of the policy decision process and to determine the inputs and outputs. This adaptive policy decision model analyzes the entire system of DMUs. For each DMU the performance control problem is modeled as a negative feedback and open-loop control process without the need to estimate the transition probabilities and the policy rewards.

The relationship between the process learning (PL) and the efficiency frontier dynamic is established through process desirability functions characterized by the output quality and the process learning rate. Improvement in PL reflects, therefore, improvement in the process quality and learning that can occur autonomously or may be induced through knowledge development policies (see Fine, 1986; Rajagopalan, 1998; Dorroth et al., 1994). The process desirability is modeled employing a generalization of Harrington (1965)'s desirability function proposed by Derringer and Suich (1980). Using this function, we then define the process quality function, allowing flexibility for policies to be targeted to a specific output or process as well as considering imprecision. At any period, the effectiveness of the DMU performance improvement policy determines its relative position with respect to the efficiency frontier, or competitiveness.

The goal for developing this model is to present a structured approach for studying the relationship between asynchronous policy cycles and efficiency dynamics in complex production systems. To the best of our knowledge, there is no existing work employing DEA or MPI that follows our approach. The model have been developed employing C++, MySQL, and cplex. An example demonstrates the functionality and practicality of this modeling approach. We argue that integrating mathematical programming, process learning, and simulation in this manner can improve the utility of DEA/MPI for supporting decision-making in real world application both in public and private sector operations.

Stream C21 – Applications V

P-102

Estimation of technological efficiency of research units

Abbasi F.,Hajihoseini H.

This paper is an empirical assessment of relative efficiency of R&D projects. Data envelopment analysis (DEA) has received significant attention in different areas as a powerful tool for measuring the relative efficiency of Decision Making Units (DMUS), which was introduced by Charnes et al. (1978). This report discusses how outputs (and inputs) should be measured in the governmental R&D units and how they could be used in technological efficiency studies. The paper also includes an application of these ideas to IROSTâ€™s Research institutes. The results of using a multi-stage DEA methodology to

assess the relative technological efficiency of 167 Iranian R&D projects are reported. Outcomes are obtained from 13 different R&D units with respect of 4 research fieldâ€™s categories (Electronic, Mechanic, Chemistry and Agriculture). Tobit and OLS regressions are used in an effort to identify further determinants of technological efficiency. The results suggest that applying project management techniques can arises technological efficiency of R&D projects.

Keywords: R&D units, Technological, Efficiency, IROST, DEA

P-037

The relative efficiency of the public institutes on economics research in Mexico City

Sigler, Luis.

The main purpose of this paper is to discover the relative efficiency of the public institutes on economics research in Mexico City during 1990 to 2002 using the Data Envelopment Analysis. Dice to that the Mexican government is the one in charge to provide scientific research on economics, due to the incapacity of the market for it (high costs and risk), this work pretends to reveal the correct use of the public resources, in specific about the research on economics. One more objective is to verify inefficiency presence between the public institutes on economics research due that the public production usually is obtained in monopoly situations. We argue that the relative efficiency of the public institutes on economics research in Mexico city during this period has been very varied and heterogeneous. In this work we offer an only, unpublished and reliable data base of the productive activity from the Mexican researchers on economics. The methodology consists in extract bibliometric indicators from the CONACYT data base (Consejo Nacional de Ciencia y Tecnologia, National Council of Science and Technology of Mexico) by date, region, institution and researcher. This indicators are two: individual papers and books from researchers associated to the SNI (Sistema Nacional de Investigadores, National System of Researchers). The SNI only recognizes researchers that produce quality scientific knowledge, for that reason we balance both factors: quality an quantity, this to obtain an equitable work. Once we extract the bibliometric indicators we applied the DEA by year to construct graphically an optimal border and determine the best units.

Keywords: Public institutes on economics research, Mexican productivity on economics.

P-084

Market share and technical efficiency: an empirical analysis for Italian cooperatives

Ornella Wanda Maietta, Vania Sena

This paper analyses the mechanisms through a larger market share can induce cooperative firms to improve technical efficiency over time in order to guarantee positive profits. This hypothesis is first formalised in a partial equilibrium framework and then is tested on a panel of Italian cooperatives. Technical efficiency indices are computed by estimating parametric production frontiers. Conventional measures of market share are used to analyse their impact

on firms' efficiency. The results support the hypothesis that a larger market share can affect positively the efficiency.

Keywords: technical efficiency, market share, cooperatives

Stream D21 – DEA/MCDA I

P-077

The efficiency analysis for DMU using the integration method of DEA and AHP

Tae-Sung Kim

This study compares and combines two techniques in Data Envelopment Analysis (DEA) and the Analytic Hierarchy Process (AHP) in the evaluation of decision making units (DMUs). DEA evaluates the quantitative data set, employs linear programming to weight the inputs/outputs and ranks the performance of DMUs. The AHP evaluates the qualitative data retrieved through expert opinions and other managerial information in specifying the weights. The objective of this research is to design a decision support process for managers to incorporate the positive aspects of the two methods, the DEA absolute numerical evaluations and human preference structure values in AHP. It is believed that the pragmatic manager will be more receptive to results that include subjective opinions incorporated into the evaluation of the efficiency of each DMU's efficiency when the AHP and DEA are combined simultaneously.

Keywords: Analytic Hierarchy Process, Priority Weight, Integrated Efficiency, Quantitative Data, Qualitative Data

P-027

An interactive MOLP method using the gradient projection approach in locating the most preferred solution in DEA and efficiency analysis

Yang JB, Wong BYH

This paper presents a new direction towards the extension of Data Envelopment Analysis (DEA) through the use of a Multiple Objective Linear Programming (MOLP) method. DEA and MOLP are two of the foremost areas within the field of operational research and are extensively applied as tools and techniques to aid the decision making process. With much of the similarities between DEA and MOLP, the paper seeks to further enhance the compatibility and establishes the equivalence model between DEA and the minimax formulation in MOLP. An interactive tradeoff analysis using the minimax method based on the gradient projection and local search approach is applied on DEA problems to assist the decision maker to search freely for the most preferred solution (MPS) on the efficient frontier within each Decision Making Unit (DMU)'s reference set. The gradient projection is conducted through the identification of normal vectors on the efficient frontier and preference information will be elicited from the DM in order to determine the tradeoff directions and step sizes. The search process will be terminated once a best compromised efficient point or MPS is generated. The interactive DEA and MOLP (DEA/MOLP) approach will provide

better estimates for measuring efficiency that incorporates decision maker's preference structure and allow for target setting and resource allocation between inputs and outputs. An application on the performance measurement and efficiency analysis of retail banks in the UK is examined.

Keywords: Data envelopment analysis, Multiple objective linear programming, Interactive tradeoff analysis, Bank efficiency, Performance benchmarking

P-021

A multi-criteria approach to technological progress, efficiency change, and productivity growth in global telecommunications

Emilyn Cabanda, M. Ariff and Viverita Yosman

This paper examines total factor productivity (TFP), efficiency change, and technological progress in 39 samples of global telecommunications during the period 1989 to 1998. The approach uses DEA-type Malmquist productivity index to determine the differences of telecommunications performance between countries or regions. We partitioned our data sets into four regional groupings, namely: Africa, Asia-Pacific, the Americas, and Europe. Empirical results suggest that Europe has obtained the highest productivity growth in telecommunications infrastructure, followed closely by the Americas and Asia Pacific. We indicate that technological progress is highly correlated with the increased TFP growth in these regions rather than efficiency changes. We also found that Africa shows a greater potential for telecommunications productivity growth as evidenced by positive changes both in efficiency and technology. However, we found that general TFP growth across the whole sample of countries has declined, owing mostly to low innovation rather than increased efficiency. This empirical result has policy implications of investing more on advanced technology to boost technological capability of the telecommunications sector in the world and introducing market reforms such as competition.

Keywords: DEA; efficiency change; technological; telecommunications; total factor productivity

Stream E21 – Banking III

P-060

Productivity decomposition in European banking with accession economies: An application of parametric & nonparametric Malmquist techniques

Fethi,M.D., Olgu, O. and Weyman-Jones, T.G.

Performance measurement studies are inevitable for unique harmonization and equilibrium throughout the European banking. The industry is recently experiencing structural changes with the enlargement process of ten new accession and three candidate countries including several transition economies with newly liberalised markets. This study aims to analyze a panel data of European banks from 22 different countries in two groups (13 EU member and 9 accession countries) to investigate whether the enlargement process had an effect on

productivity growth and to identify the productivity gap - if exists among these groups- over the period of 1997-2002. The empirical measurement in the paper is based on the comparison of a time-varying stochastic parametric distance function, with conventional DEA. This function is used to generate two different parametric stochastic estimates of Malmquist productivity indices as suggested by Fuentes, Grifell-Tatje and Perelman (2001), and Orea (2002).
Further, we decompose the productivity index into technical efficiency change, technological change and economies of scale change components.

Keywords: Productivity, European banking with accession countries, distance function estimation.

P-094

An analysis of the relevance of off-balance sheet items in explaining productivity change in European banking

Casu B., Girardone C.

The 1990s have witnessed a significant growth in bank income generated through non-traditional activities especially for large EU universal institutions. Using the non-parametric Malmquist methodology this paper analyses the importance of the inclusion of off-balance sheet (OBS) business in the definition of banks output when estimating total factor productivity change indexes. The analysis is then extended to the decomposition of total factor productivity change into technical efficiency and technological change. The results reinforce the prevalent view in the recent literature, indicating that the exclusion of non-traditional activities leads to a misspecification of banks output. In particular, the inclusion of OBS items results in an increase in estimated productivity levels for all countries under study. However, the impact seems to be the biggest on technological change rather than efficiency change. Overall, results suggest that despite the uneven distribution of OBS between countries and among different institutions in the same country, these non-traditional activities are increasingly important and failure to account for them would lead to biased conclusions.

Keywords: Finance and Banking; Productivity Change; Malmquist Index; DEA

P-068

Opening the black box: finding the source of cost inefficiency

Santiago Carbó Valverde, David B. Humphrey, and Rafael López del Paso

Using parametric and nonparametric procedures, we identify the apparent source of cost inefficiency in banking. Unexplained inefficiencies of 20 to 25% from earlier studies are reduced to 1 to 5% when, in addition to commonly specified cost function influences, variables reflecting the external business environment and common industry indicators of "productivity" are added. While these same productivity indicators explain most of the reduction in bank operating cost over time, cost reductions during 1992-2001 were 5 times the reduction from improved efficiency. This helps explain why inefficiency appears stable over time – it is small relative to industry – wide cost changes occurring concurrently.

Keywords: Cost efficiency, Financial Institutions

13.45 – 15.00 Discussion Papers

Discussion Papers I

P112

Hospital Efficiency: A Study of Public Community Hospital in Thailand

Pavananunt, Kanyakorn.

The objectives of this study were to examine the level of technical efficiency of public community hospitals in Thailand and to explore factors determining their efficiency. The study was conducted in two stages of analysis; the first stage, technical efficiency scores were estimated by using the fixed-effects panel data model with appropriate hospital specific inputs and outputs. In second stage, a number of independent variables were included in the multiple regression model in order to test for the relationship with technical efficiency scores. There were 662 public community hospitals included in this study. A panel data set for five consecutive years from 1996-2000 were employed for the analysis of technical efficiency scores. The main types of data used for the analysis were service outputs indicators and inputs or resources used for service providing. Service outputs included; outpatient visits, inpatient days and accident -emergency cases. Inputs or resources used were; capital expenses, labor expenses and material/supplies expenses. The primary data was also used for the study of factors determine the public hospital efficiency The primary data were collected through a survey questionnaire which was specifically designed for this study. A 5-point scale Likert type items were used to measure the constructs in our hypotheses. The questionnaire was sent to the 605 respondents of the 289 public community hospitals. The response rate was 42 percent. The result of efficiency estimation indicated that there was a wide variation of technical efficiency scores among different size of community hospitals. Larger size hospitals tend to be more efficient than smaller size hospitals. There was also a wide variation in technical efficiency scores even we control for size. The distribution of efficiency scores among 662 community hospitals cluster around the efficiency scores of 0.05-0.63 with a mean value of 0.55. The hospital which stand out as relatively more efficient than others with efficiency score of 1 was the largest size of community hospital with 120 beds. The hospitals were ranked into four groups using the estimated efficiency scores. Among the 662 hospitals, 11% of hospitals were ranked in the most efficient group, 42% were in moderate efficient group, 38% were in low efficient and 9% in least efficient. The results suggested that there are ample opportunities for improvement in technical efficiency among public community hospital in Thailand. The result of determinants study indicated that five out of nine independents variables were statistically significant associated with technical efficiency scores. The determinants were classified into two categories; internal and external factors. The internal factors included age of hospital, size of hospital and managing human resource factor. The external factor included community demographic (number of population) and competitive environment (number of private hospital and clinic). The determinants study provide the policy maker and administrators with information for policy formulation and further study of hospital efficiency after the reform of health service systems in order to improve the efficiency of public community hospitals in Thailand.

Keywords: Hospital Efficiency, Fixed-effect model, Technical efficiency

P-111

Benchmarking the Economic Performance of Portuguese Water and Sewerage Services

Marques R, Monteiro A.

Benchmarking generally refers to the process of comparing the performance of an organization with a standard. Due to their features, the benchmarking tools are crucial in the water and sewerage services (henceforth WSS). Data Envelopment Analysis (DEA) technique is one of them. DEA is a frontier method based on linear programming techniques for assessing the comparative efficiencies of organizations, such as WSS. For almost two decades, DEA has already been used in the water and sewerage sectors, in a lot of countries (USA, UK, Australia, Japan, Denmark, The Netherlands, Italy, Brazil and others), by different actors (regulators, financial agents, WSS and academics) with several objectives (economic regulation, investments assessment, efficiency earnings, research,). This document employs the DEA method to determine efficiency measures of a set of 69 Portuguese WSS, corresponding to about 64 % of the Portuguese population. It begins with a brief introduction explaining the benchmarking methodologies and stresses their weaknesses and strengths. Section II describes and discusses the DEA method and its main WSS publications until now. Section III defines and analyses the DEA models applied to the Portuguese WSS. Section IV computes the developed models for the Portuguese WSS and depicts the observed outcomes and their explanatory factors. Section V concludes the paper.

Keywords: Benchmarking, data envelopment analysis, water and sewerage services efficiency

Discussion Papers II

P-082

Corporate Performance of Indonesia's Public and Private Sector Firms: Financial and Production Efficiency

Viverita and Ariff M

This paper reports findings from a research on corporate performance of public sector and private sector firms in Indonesia. The study employs two production efficiency measures: DEA-Malmquist and Stochastic Frontier- and the traditional accounting-cum-financial measures. The results show declines in productivity of about 8 percent over the study period. Greater part of this decline is attributable to technological inefficiency. The accounting- cum-financial performance measures also indicate poor performance gains for the return to capital measures while further investigation reveals lackluster performance. Examining the public versus private sector firms, the results reveal that efficiency gains are mixed. However, the performance during the period of Asian economic crisis in 1997-98 actually declined by massive amount. Investigation of the factors contributing to the performance indicates three firm-specific factors as being correlated with performance.

Keywords: DEA-Malmquist; productivity gains; state-owned enterprises; private sector firms; total factor productivity; financial performance

P-161

Efficiency measurement of hemodialysis units in Greece with data envelopment analysis

N. Kontodimopoulos and D. Niakas

This paper reports on a study of the suitability of Data Envelopment Analysis for measuring efficiency of hemodialysis units in Greece. The sample consists of one hundred eighteen such units operating in the public and private sector. Production characteristics were designated in terms of two input measures --nursing staff and dialysis machines-- and one output measure, namely the number of patients treated per month. The DEA model selected was input oriented, allowed for variable returns to scale and the units were ranked according to a benchmarking approach. The results yielded mean efficiency scores of 65.04% and 82.21% for the public sector and private sector units respectively. Independent sample t-tests showed statistically significant differences between these scores. The units were also classified, according to location, as either being in Athens, Thessalonica or another region and the procedure was repeated. The results yielded mean efficiency scores of 58.89%, 61.48% and 67.51% respectively. Comparison, in this case, indicated significant differences between the public sector units located Athens from those located in Thessalonica or elsewhere. The overall findings are encouraging for the potential of DEA in this setting and generate the need for further research in order to validate any conclusions.

Keywords: Data envelopment analysis, Efficiency measurement, Hemodialysis, Greece

Discussion Papers III

P-065

Segment selection through DEA in marketing

Ranjeet Khaira and Mark Gabbott

The concept of market segmentation is based on the premise that partial homogeneities exist in the market place and that by homogenizing customer needs segments can be created. However, while the process of grouping and aggregating customer needs creates segments, this process does not ensure segments created are attractive or of value to the business. To be able to differentiate the attractiveness of a segment, it is necessary to be able to derive a measure of attractiveness that delineates segments that are attractive from those that are not, or provide a hierarchical ranking of attractiveness.
This paper aims to introduce relative efficiency, derived through Data Envelopment Analysis (DEA), as a means of assessing attractiveness that enables businesses to compare the attractiveness for various segments. As segments consist of customers, both financial and behavioral measures (in the form of behavior propensity scores) will be used to derive relative efficiency. This paper also presents a three-step filtering approach to segmentation

and provides three examples that demonstrate the application of relative-efficiency in adding dimensionality to segment selection, in the versioning of offers and in assessing the attractiveness of strategic target market segments that are untapped. It is anticipated that by introducing relative efficiency as a measure of attractiveness, businesses will be able to differentiate the attractiveness of a segment based on multiple dimensions simultaneously. This will enable businesses to direct resources to segments that are deemed to be more attractive, thereby enhancing the normative capabilities of segmentation in marketing.

P-005

Banking reforms and banking efficiency in Libya: Non-parametric approach 1980-2000

Alwaadan,.A and Taghavi, M.

Most studies aimed at measuring efficiency in banking have primarily used financial indicators/ratios as the only sources of inputs and outputs. This is a valid approach, provided that banks are assumed to apply identical managerial techniques and enjoy similar quality characteristics. In this paper, however, we attempt to incorporate such qualitative aspects into our measurement of efficiency scores.
This paper investigates and analyses the efficiency performance of Libyan commercial banking sector over the period 1980-2000. This period is characterised by government control over the economy and the increasing macroeconomic instability. The overall technical efficiency, pure technical, and scale efficiency of commercial banks are measured, using non-parametric Data Envelopment Analysis (DEA) in conjunction with financial ratios. Two scenarios have been employed to show how efficiency scores vary with changes in outputs and inputs. Moreover, another scenario has been constructed to highlight the impact of non-performing loans on banking efficiency.
In order to investigate the efficiency of managerial aspects, a questionnaire was designed and used to appraise the potentials of internal audit function of the selected banks. The indices of managerial/auditing performance have then been included in the model. The results reveal that initial reform policies seem to have a slight impact on banking efficiency. The findings suggest that the average technical efficiency ranges from 76% to 96%. It also emerges that scale efficiency is the main source of technical inefficiency. In addition, score efficiency in conjunction with financial ratios suggest that banks with high efficiency scores also exhibit high scores in capital adequacy, asset utilisation, and liquidity position, and lower ratios in profitability, and asset quality. Finally, in terms of audit function efficiency, results show that banks with high technical efficiency tend to have higher efficiency in auditing function.

Keywords: Banking efficiency; Technical, pure, and scale efficiency; Financial ratios; internal audit function

Discussion Papers IV

P-072

Short-run Profit and Productivity of US Class I Railroads

Lim, SH

In the face of shrinking market share, rising rail cost and falling rail rate, the success and sustainability of the railroad industry depend largely upon increased productivity. The objective of this paper is to examine how short-run profit changes can be attributed to changes in productivity in the railroad industry, given the fact that improvements in productivity do not necessarily imply increases in short-run profit. Though numerous studies have attempted to examine railroad productivity in recent decades, the existing economics literature has paid very little attention to this phenomenon. Using an unbalanced panel of US Class I railroads for the period of 1986 - 2000, a short-run profit change decomposition model is used to attribute intertemporal short-run profit change to its causal factors. The model is performed using sequential DEA. Unlike the conventional approaches to productivity and efficiency measures, this technique uses Bennet input price and quantity indicators to examine the relation between profit and productivity of the railroad industry.
Keywords: Sequential DEA, Bennet price and quantity indicators

P-002

Measuring Weight Flexibility in Data Envelopment Analysis Using Cluster Analysis Results

Backhaus, K., Wilken, R.

In traditional Data Envelopment Analysis (DEA) the efficiency of a decision-making unit (DMU) compared to other DMUs is measured by choosing DMU-specific optimal weights for all input-output-variables. The only underlying constraint for the weights is non-negativity. The so-called weight flexibility is often discussed as a main weakness of traditional DEA. Although some concepts have been discussed which try to solve this problem (i.e., the cone-ratio-method), there is little knowledge about the degree to which weight flexibility influences DEA results.
This paper introduces the Cluster Analysis (CA) as an instrument for measuring weight flexibility in traditional DEA. We compare CA results (using Q-correlation as similarity measure) with raw input-output-data on the one hand and virtual input-output-data on the other. The weight flexibility can be expressed by the ratio of the two identified cluster-heterogeneities. The higher the score, the higher weight flexibility in the used DEA model.
The proposed method is empirically tested with 72 American and European MBA-programs as DMUs. Using raw data, CA produces two nation-specific clusters, whereas traditional DEA seems to ignore these structures. CA results can therefore be used to put DEA results into perspective. Additionally, DEA models with variable returns-to-scale tend to yield higher weight flexibility scores than models with constant returns-to-scale.

Keywords: Cluster Analysis, Weight Flexibility

15.15 – 16.30

Stream A22 – Theory VII

P-117

Solution for multiplier variables and non-Archimedean constant in DEA models

O'Brien G.C. and Wu L.

After discussing solutions for the multiplier variables of various DEA models, including the original solutions for the multiplier variable of the CCR ratio model and the solutions for the multiplier variable of the CCR transformed equivalent models, the BCC models, Additive Models, and Multiplicative Models, this paper discusses the imposition of a non-Archimedean constant in the Additive and Multiplicative Models.

Keywords: data envelopment analysis (DEA); fractional programming; linear programming

P-118

Random effects logistic model for Data Envelopment Analysis

Sohn SY and Choi H

Data Envelopment Analysis (DEA) is a useful nonparametric method to evaluate the relative efficiency of a set of decision-making-units (DMUs) with multiple inputs and outputs. In some realistic applications, in addition to inputs and outputs, environmental factors that describe the nature of DMU can play important roles in the efficiency analysis. For more successful DEA application, it is required that the analyst have the knowledge on the environmental factors in addition to the related inputs and outputs of DMU. In this paper, utilizing such environmental factors, we consider a random effects logistic regression model for DEA. A beta distribution is assumed for the variation over the probability that a randomly selected DMU from a homogeneous group with the same environmental characteristics is efficient. This model accommodates potential correlation among individual DMUs within homogeneous group. A case study is presented in the context of efficiency analysis of technology commercialization projects in the area of information technology (IT). It is expected that our proposed approach can complement the DEA results with environmental factors and at the same time it facilitates the prediction of the efficiency of a new group with limited information.

Keywords: Random effects model, Information technology

P-032

Using geometric programming to solve an improved nonlinear multiplicative DEA model

Kazemi M., Moini A., and Asgharpour M.J.

The main goal of this paper is to introduce a nonlinear DEA model for relative efficiency of the firms working closely with the comparison of the Iranian Electricity Distribution Sector. DEA is basically a linear programming technique used for measuring the relative efficiency of decision making units. For the purpose of the study, a nonlinear DEA model is offered. CCR_O DEA as well as nonlinear DEA model are applied to evaluate the efficiency of Electricity Distribution in the country. We have also suggested taking Geometric programming to solve the nonlinear model.

Keywords: Data envelopment analysis (DEA), Nonlinear DEA model, CCR_O model, Geometric Programming, Evaluating the efficiency, Electricity distribution in Iran.

Stream B22 – Health II

P-012

Technical efficiency and total factor productivity growth of hospitals in Ireland

Brenda Gannon and Brian Nolan

Similar to many other European countries, the funding system for Irish hospitals is partially based on casemix, whereby resources are redistributed annually, to hospitals with greater efficiency. For this reason, accurate measurement of efficiency is essential, so in this paper, we use Data Envelopment Analysis to measure technical efficiency of acute hospitals in Ireland between 1992 and 2000. We split the sample into the different types of services provided and this also overcomes the potential problem of biasing the efficiency estimates because hospitals vary in size. Our inputs are number of beds per hospital and numbers employed, and we use the number of discharged inpatients and outpatients as a measure of output. While our output measure is not adjusted for casemix, it is useful for obtaining initial estimates of technical efficiency in Irish hospitals and we show that our results are in the same range as those obtained recently for hospitals in Northern Ireland. We later use a measure of output adjusted with DRG weights and determine whether or not efficiency estimates are different to those found when we use the simple measure of output. Using data from HIPE (Hospital In-patient Enquiry), it is possible to construct this output. We weight the number of inpatients in each DRG (511 in total) and aggregate to a single measure of output per hospital. We then estimate technical efficiency using DEA, and compare our results with the initial estimates based on inpatients discharged. In this paper, we also use the Malmquist Productivity Index to analyse changes in technical efficiency during the same period. This allows us to decompose changes in efficiency over time into technological change, pure efficiency change and scale efficiency change.

Keywords: Hospital Efficiency, DEA, Malmquist Index

P-106

Non-parametric approaches to education and health expenditure efficiency in OECD countries

Afonso, António, St. Aubyn, Miguel

We address the efficiency of expenditure in education and health sectors for a sample of OECD countries by applying two alternative non-parametric methodologies: FDH and DEA. Those are two areas where public expenditure is of great importance so that findings have strong implications in what concerns public sector efficiency. When estimating the efficiency frontier we use both measures of expenditure and quantity inputs. We believe this approach to be advantageous since a country may well be efficient from a technical point of view but appear as inefficient if the inputs it uses are expensive. Efficient outcomes across sectors and

analytical methods seem to cluster around a small number of core countries, even if for different reasons: Finland, Japan, Korea and Sweden.

Keywords: expenditure and education, expenditure and health, expenditure efficiency, production possibility frontier, FDH, DEA

P-101

Relative efficiency of some selected hospitals in the Accra-Tema metropolis

Kwakye, E.

As hospitals form the biggest institutional provider of health care in Ghana, efforts to improve efficiency in health delivery include analysis of hospital efficiency. Few such studies have been done in Ghana despite growing literature on health sector reforms and poverty reduction through health. This study, the first of its kind in Ghana, evaluates the relative efficiency of twenty hospitals in the Accra-Tema Metropolis using data envelopment analysis, with given data limitations. The number of outpatient visits and inpatient days are used as measures of hospital output with physicians, nurses, support staff and beds used as measures of input. With aggregate efficiency scores ranging from 0.31 (least efficient) to 1, the results indicate that some hospitals (9) are not maximizing health service provision from the resources available to them compared to their efficient counterparts. There seem to be no marked differences in the efficiency levels of private-, quasi- and government-owned hospitals. A greater proportion of private hospitals however turn out to be efficient with the least proportion being quasi-government owned hospitals. Pure technical inefficiency tends to be more pronounced than inefficiency attributable to decreasing returns to scale. A censored Tobit regression analysis of inefficiency scores shows that higher occupancy rate and a greater proportion of outpatient department activity to inpatient days minimize inefficiency, but type of ownership does not explain hospital efficiency. Contracting out OPD activities to some under utilized facilities, relocation of some staff category, redefining jobs of some skilled health workers are among several recommendations made to improve efficiency.

Keywords: Hospital efficiency

Stream C22 – Agriculture II

P-035

The measurement of technical efficiency and its determinants of olive growing farms in Tunisia

Lachaal L, Dhehibi B, Karray B and Chebil A

The olive oil sector is an important ingredient in the Tunisian economy in terms of employment and income generation. In the year 2000, this sector produced 1125 millions tons of olive oil, which amounted to 10% of the value of agricultural production and contributed to 1.17% in the growth of domestic product. Furthermore, olive oil production, which grew at an annual rate of 6.6% during the 1990-2000 period, is an important source of foreign exchange earnings, accounting for 46% of agricultural exports. Given the importance

of this sector in the national economy, an important policy issue in the last two decades has been to make this sector more competitive by furthering production growth and increasing exports. Knowledge of the relative contribution of factor productivity and input use to output growth and improvements in technical efficiency are crucial to provide a comprehensive view of the state of the olive oil sector in the country and help farm managers and policy makers to draw appropriate policy measures. The objectives of this paper are twofold: Investigate farm level technical efficiency of olive production using cross section data on 100 olive producing farms in central Tunisia; Analyse the determinants of technical efficiency variation among these farms. To reach these objectives, we estimate a stochastic production frontier translog model in which technical efficiency effects are assumed to be a function of farm specific variables; i.e., (1) share of olive trees in deep soil (SP), (2) share of old trees (PPA), (3)share of skilled labour (MOQ) and (4)irrigation schemes (IRI); (Kumbhakar et al., 1991; Huang and Liu, 1994).
Preliminary estimation results indicate that the inefficiency effects are significant in determining the level and the variability of farm production in the sample. The signs of the coefficients of the stochastic frontier are consistent with our expectations. The estimated coefficients of the share of olive trees in deep soil (SP), the share of old trees (PPA), the share of skilled labour used (MOQ) and irrigation variable (IRI) in the technical inefficiency model are negative and significant at the 10% level.
Conclusions and policy implications: Estimation results of the technical inefficiency effects model suggest that the share of olive trees within deep soil (SP), the share of old olive trees (PPA), the share of skilled labour (MOQ) and irrigation operation (IRI) variables have a significant and a positive relationship with technical efficiency. These results could have important implications as far as the crucial role of government policies in: (a) promoting and encouraging the replacement of old olive trees on deep soil; (b) training, through extension activities, farmers to help them improve their pruning skills; and (c) encouraging irrigation schemes whenever water is available.
The estimated technical efficiency of olive production in the sample varies considerably, ranging from 58.9% to 98.2, with a mean value of 83.5%. This indicates that, on average, olive farmers could increase their production by as much as 16.5% through more efficient use of production inputs.

Keywords: Technical Efficiency, Olive growing farms, Tunisia.

P-127

Productive efficiency evaluation of agricultural sector of municipal districts of AMUSEP (Associação dos Municípios do Setentrião Paranense)

M. F. Pereira

Brazilian agricultural sector has experienced an important process of modernization since the 1970's which main effects include advances in technological progress and gains in productivity. However, the significant progress made in this sector of the economy was concentrated in only some regions of the country. A case is the sandstone region in the northwest of Paraná, where the system of cattle production hardly ever uses any technology, which provide productivity gains. Concerning this fact have we developed a study in the municipal districts of AMUSEP with the main aim of evaluating the relationship among productive efficiency, soil type and the exploration activity. The methodology used was based on Data Envelopment Analysis (DEA) and partial indicators. The results evidenced

that the agricultural activity, which does not depend on the type of soil, has influenced the productivity levels as well as the productive efficiency levels.

Keywords: Productive efficiency, soils, agricultural sector, DEA.

P-122

Data Envelopment Analysis versus the Canonical Correlation Theory: an empiric application to the Spanish wine producers

Isidoro Guzman

Using a test based on canonical correlation theory, this paper examines the combination of variables in Data Envelopment Analysis (Sengupta, J.K., 1990). This technique provides the largest degree of correlation between two groups of variables (inputs-outputs), helping to the design of the DEA's models. A second objective of the study, following the approach adopted by Smith (1990), is concerned with the technical efficiency's indexes based upon accounting information. The DEA performance index allows this association with traditional financial analysis (Yeh, 1995). An empirical application to Spanish wine producers has been carried out. The results demonstrate the usefulness of canonical correlation theory to DEA, while also presenting the relationship between the DEA's indexes and several financial ratios.

Keywords: canonical correlation, financial analysis, Spanish wine producers

Stream D22 – DEA/MCDA II

P-007

A Multi-criteria methodology as framework of performance evaluation through DEA and justifiability of averaged combined ranking through a concordance test

A C Majumdar

The paper deals with two important aspects relating to organisational performance evaluation through DEA application.
Firstly, it has been emphasised that traditional DEA measure of "Efficiency" in the form of the ratio of weighted aggregate of outputs and weighted aggregate of inputs with endogenously selected weights evidently signifies only a measure of *Productivity*. However, every enterprise explicitly or implicitly develops plans or targets for both usage of resource inputs as well as achievement of resulting outputs. As such, two other important measures of performance, should also be considered, which are:

- *Efficiency* (as distinct from the sense used in traditional DEA definition), depicting the results of input (resource) planning as a ratio of inputs actually used and inputs planned to have been used, and

- *Effectiveness*, reflecting output planning as a ratio of output actually achieved and planned output.

Secondly, it has been argued that ranking of DMUs in DEA either on the basis of average ranks according to *a particular* performance measure over a number of operational years or average ranks of *several* performance measures over the years and finally overall average of *combined* ranks, if any, are significantly important for efficiency evaluation.

Therefore, averaging or combining the ranks over *time* or across *different performance measures* without ascertaining reasonable agreement among the ranks may not be justified. If the rankings for different time periods or for different performance measures show a reasonable degree of concordance, only in that case such ranks can be combined and averaged.

It has, therefore, been proposed in the paper that before ranks of a DMU are averaged, concordance among the rankings should be checked through Kendall's Co-efficient of Concordance. An insignificant value of the Co-efficient, if obtained, would hardly justify averaging.

The present work embraces seventeen DMU's traced over four consecutive years. Values for three different performance measures proposed, viz., *Productivity* (defined as "efficiency" using output and input in traditional DEA sense); *Efficiency* (based on input planning and usage) and *Effectiveness* (based on output target planning and achievement) have been calculated applying DEA in each case and efficiency frontiers have been developed. The DMUs have then been ranked on the basis of cross matrices for different performance measures.

While considering average rankings, concordance check has been made based on the average rankings of performance measures with respective *operational years as the judges,* separately for each of the three measures of performance, and also average ranks of the DMUs on the basis of four-year average ranking with respective *performance measures as the judges*.

As a contribution to management science, the paper indicates possible distinct uses of DEA based on three different measures and ranking of the DMU's objectively to provide corporate management with areas of introspection, review and rework in the context of strategic decision making rather than rough and ready results.

Keywords: Performance Measures; Productivity; Efficiency; Effectiveness; Averaged Ranking; Co-efficient of Concordance; Judges.

P-086

Preference structure and incorporating value judgments in DEA

WB Liu, W Meng, and J Sharp

It is important to reflect decision makers' preference in performance evaluation. In our view, value judgments of decision makers can be incorporated into DEA models more directly and explicitly by exploring preference structure. In fact, it forms a building block of DEA models. In this talk we shall illustrate, through a real application, how to incorporate value judgments in DEA models via this approach.

Keywords: DEA Models, Incorporating Value Judgments

Stream E22 – Applications VI

P-196

Managing performance of organisational units with PIMsoft: A new DEA software

Ali Emrouznejad and Emmanuel Thanassoulis

DEA literature continues apace but software has lagged behind. This session uses suitably selected data to present newly developed software which includes many of the most recent DEA models. The software enables the user to address a variety of issues not frequently found in existing DEA software such as:

-Assessments under a variety of possible assumptions of returns to scale including NIRS and NDRS;

-Scale elasticity computations;

-Numerous Input/Output variables and truly unlimited number of assessment units (DMUs)

-Panel data analysis -Analysis of categorical data (multiple categories)

-Malmquist Index and its decompositions

-Computations of Supper efficiency

-Automated removal of super-efficient outliers under user-specified criteria;

-Graphical presentation of results

-Integrated statistical tests

P-057

Measure of firms inefficiency and heterogeneity using nonparametric frontier models: The Cote d'Ivoire case

Roudaut N, Vanhems A.

The objective of this work is to estimate the production frontier and technical efficiency levels of Cote d'Ivoire firms. The methodology used is closely linked to recent nonparametric frontier models developed by Cazals, Florens and Simar (2002), Aragon, Daouia and Thomas-Agnan (2003) or Florens and Simar (2001). The main advantage of this approach, compared to the classical nonparametric methods (DEA, FDH), is the robustness to outliers. We show that these latest techniques are in particular more adapted to our database. We also modelise the technical efficiency by introducing external environment factors that might influence the production process. Using bootstrap techniques, and following the ideas from Simar and Wilson (2003), we take into account the heterogeneity of our database and explain the variability of firm performance.

Keywords: Nonparametric Methods, Expected Frontier, Quantile Frontier, Parametric Approximation, Business Environment, Manufacturing Firms

P100

An application to the estimation of productive efficiency based on non parametric techniques the case of electricity distribution in Argentina

Margaretic, P; Romero, C

During the last decade, Argentina has faced an extended process of privatisation in utilities sectors, in particular, electricity. One of its main objectives was to increase the efficiency in the supply of these services through the transfer from public to private ownership and through the adoption of more powerful incentive schemes that allow using benchmarking methodology between firms, such as price caps regimes. The evaluation of the results of this process implies developing objective measures to screen the functioning and the operation of the different natural monopolies through time in order to promote competition, give incentives to cost minimization and ensure that, eventually, users benefit from these cost reductions. Additionally, the efficiency measurement is useful for price reviews. In such a case, the regulatory challenge is the following. If the efficiency gain used to fix the new price cap is specific to firm and is based on past gains, the firm would not have incentives to reduce its costs in the future. However, if the expected efficiency gains for the next period were based on the aggregate development of the industry, the firm would have incentives to be more efficient and to produce at a lower level of costs than the average of the industry. One of the main instruments to measure the efficiency of utilities is the efficiency frontier. They can be classified in terms of the type of specification of the frontier itself: a production function, or a cost function. In this selection, there is another implicit choice, regarding the type of efficiency to estimate. The production function estimates technical efficiency, while the cost function gives a measure of productive efficiency. The decision between them must take into account the kind of sector under analysis. Efficiency gains from a firm can come from two main sources: shifts in the frontier reflecting efficiency gains at the sectoral level and efficiency gains at the firm level, reflecting a catching up effect. The latter are the gains to be made by firms not yet on the frontier. These firms should be able to achieve not only the industry gain but also specific gains offsetting firm specific inefficiencies and the regulator should take into account this decomposition. In the distribution of electricity in Argentina, there are 25 firms: 18 private firms and 7 public firms, subject to jurisdictional regulation, with their own regulators and different legislation. Baldwin and Cave (1999) identify a number of conditions for a successful implementation of a benchmarking methodology: a considerable number of comparable firms, a common regulator, and enough data for all the firms. In this paper, we count with a set of 18 regional firms specialised in the electricity distribution activity in Argentina for a relatively long period: 1993-2002. The number of firms and the information available for each one is long enough. Even though there is not a common regulator between them, the different legislations are not so different, which make them comparable. Therefore, we fulfill the conditions for successful benchmarking analyses. In this paper, we address all these issues and try to elaborate upon the applied aspects of the efficiency measurement in a regulatory context. We estimate the efficiency of firms based on a cost function. To measure the efficiency of utilities, we apply DEA methodology. We obtain efficiency measures for each of the firms of the set under different assumptions regarding the type of technology and the environment of operation. We consider not only the possibility that the measures are constant through the period, but also that they vary along time. Additionally, we estimate the expected efficiency gains that derive from shifts in the frontier reflecting efficiency gains at the sectoral level. In this context, the effective implementation of a yardstick competition mechanism depends on a common regulator or failing that, on a National Office like the Competition Commission. Therefore, the possibility to count with a benchmarking analysis of all these different jurisdictions

alleviates the absence of a common regulator and it contributes to reduce the asymmetry of information between the firms and regulators.

Keywords: Efficiency measurement, Electricity efficiency, cost function, benchmarking analysis

Posters

P-156

Constructing 'Data Envelopment Analysis' via performance measures: A field research from modifying the balance scorecard in a public trainning center

Athanasios G. Vasilakis, Ioannis Paggios, and Panagiotis Papadeas

The aim of the current doctoral research is to get a better insight into the appropriateness of life long training, one of the central elements of performance improvement, into organizations in general and governmental organizations more specifically. Performance measurement in governmental organisations intends to hold public managers more accountable for their results in terms of output or outcomes. However, from an agency perspective it follows that when performance is high, output or outcomes based control is less favorable than behavior based control. Training can be the result of different factors, but in the reality of governmental institutions the political influence seems to be a main source.
Training costs are categorized in direct and indirect costs. Direct costs include running the training programme, while indirect costs include employees' absence from their duties during the training period. Even though many theoretical approaches exist on performance improvement after the training period, there is not clear empirical evidence on the performance gains taking into consideration the costs. Following the pointed knowledge gap, in this text a proposed research is presented. In the next section the research objectives will be defined. Then a number of research questions and hypotheses are raised, in order to perform empirical tests. This abstract ends with a brief description of the completed research so far, and design of future research.

P-150

A DEA analysis of bank performance in Malaysia

Ismail, M and Matthews, K.

In this study, we aim to measure and decompose the technical efficiency of Malaysian commercial banks for the period between 1994 and 2000. Having obtained the efficiency scores, we then compare the relative performance amongst the banks. Using two basic DEA models, we found that the average pure technical efficiency is about 93% and the inefficiency is mainly caused the scale problem. By ownership, the foreign banks are found to have higher efficiency level, followed by the state-owned banks and private banks. Finally, we also found that the efficient banks are significantly characterised by higher profitability rate and larger asset size.

Keywords: Domestic and foreign banks, technical and scale efficiency, DEA.

P-145

Characterizing an equitable omission of shared resources: A DEA based approach

Amirteimoori A. and Kordrostami S.

In many real applications of DEA, there are often cases which the decision maker is made to omit a fixed proportion of a shared resource from all DMUs. In this paper, we present a DEA-based method for omitting a fixed proportion of a shared resource (input) from all DMUs in an equitable and fair way. Numerical results are presented for an example.

Keywords: Data envelopment analysis, equitable omission

P-148

Methodology generation applying DEA in the design of efficiency and productivity indices to the Universidad Nacional de Colombia's Extension Function

Rodriguez Gloria.

The Extension Function should be understood as an interaction process between the University and society. Thus it expresses the Universidad Nacional de Colombia's social conscience as a public and educational establishment involved with the comprehension and solution of the country's problems at a national, regional and local level, the contribution towards the formulation of public policies, the treatment for specific problems and opportunities among social agents, and the development of diverse social capabilities contributing to the improvement of social welfare and equity conditions, living standards, citizen building - up, and a democratic sense of community.
The methodology is based on the generation of different DEA models necessary to determining indices to the Universidad Nacional de Colombia's Extension Function.
The set of DMU's corresponds to the Different Basic Units of Academic and Administrative Management (DBUAAM), which develop this sort of activities.
There are currently 11 different modes (with at least other 25 sub-modes) of Extension distributed in 20 faculties, 8 institutes, and 3 frontier quarters.

Keywords: Design of Efficiency and Productivity Indices to the Universidad Nacional de Colombia's Extension Function

P-140

Analysis of efficiency of banks in Gulf States

Abdel Latef Anouze and Ali Emrouznejad

Although considerable effort has been invested in the measurement of banking efficiency using Data Envelopment Analysis, hardly any empirical research has focused on comparison of banks in Gulf States Countries.

This paper employs data on Gulf States banking sector for the period 2000-2002 to develop efficiency scores and rankings for both Islamic and conventional banks. We then investigate the productivity change using Malmquist Index and decompose the productivity into technical change and efficiency change. Further, hypothesis testing and statistical precision in the context of nonparametric efficiency and productivity measurement have been used. Specially, cross-country analysis of efficiency and comparisons of efficiencies between Islamic banks and conventional banks have been investigated using Mann-Whitney test.

P-147

Slacks-Based Measure of Super Efficiency in Data Envelopment Analysis (DEA) with Imprecise Data.(Interval and Fuzzy Data).

Davood Farbod, Abbas-Ali Noora, Mohammad-Hadi Farahi

Our aim in dissertation is to consider slacks-based measure of super efficiency in Data Envelopment Analysis (DEA) with precise and imprecise data. (interval and fuzzy data). In most models of DEA there are plural Decision Making Units (DMU) which have "efficient status". To discriminate between these efficient DMUs is an interesting research subject. several authors have proposed methods for ranking the best performers. for example : Andersen-Petersen (1993), Doyle-Green (1993-94), Stewart (1994), Toffalis (1996), Seiford-Zhu (1999) and Zhu (2001) among others. We will call this problem the super efficiency problem. Super Efficiency is technique that enables an extreme efficient unit o to achieve an efficiency score greater than one.
In this thesis introduced SBM efficiency and then super efficiency measure by using SBM (Super SBM) was Applied in Input/Output oriented and we compared [Super SBM] model with Andersen-Petersen model. Since in most cases, data are imprecise, therefore we consider super efficiency with interval and fuzzy data. [Super SBM] with interval data transformed into linear programming by Dimitris method and Cooper transformation, then with its resolution under the best conditions and the worst once an optimum solution obtains. since, optimum solution we get contains interval one ; therefore, we deal with interval ranking which a method is introduced for it. [Super SBM] problem with fuzzy data by alpha-cut method transformed into interval model.

Keywords: DEA, DMU, CCR, SBM, Super Efficiency, Super SBM, Interval, Fuzzy.

P-143

New models of DEA in deregulated economy

Verma Bharat Bhushan

Last two decades have seen deregulation in various infrastructure sector including power, telecom, railways, airlines etc. These sectors are increasingly being subjected to market forces in hope of bringing down cost of services and promoting innovation to make them more efficient. The consumers are the focal point than the efficiency and productivity. Consumer satisfaction and quick response are the better indicators of the output of firms than least cost production. DEA was invented in the era of cost regulation which focused on measuring efficiency and productivity of DMUs. Ever since its invention a number

improvements and variants have been introduced to resolve issues associated with it. In this paper, innovative way of using DEA technique to incorporate the changes in the regulatory environment have been attempted and newer DEA models have been proposed which incorporate the responsiveness of the firm to rate and rank adaptability of DMUs in market based economy than just efficient operations. The model is tested on a hypothetical electricity trading market in India. A "not-too-rigorous" mathematical treatment makes this paper an easy rapid reading text. The emphasis of the paper is on practice rather than abstract theory.

Keywords: Deregulation, Infrastructure, electricity Markets

P-158

DEA application to the analysis of Post-Office Station's efficiency

Vaz, Maurício António

Despite their diverse aims, managers and shareholders are consistently concerned with evaluating and determining the performance of their organizations. Today this question is possibly of greater importance due both to increased competitiveness and greater complexity and size of the enterprises. In this work the application of DEA methodology -Data Envelopment Analysis- to the specific Department of a State enterprise in the non-financial sector is described and the results are compared to those obtained through different methods. The methodologies used, like those of DEA, aim at obtaining a unique and simple measure of evaluating efficiency, by combining the group of outputs and inputs related to the different homogeneous units under evaluation.
The DEA method was preferred because its characteristics make it particularly adequate to evaluate homogeneous units which are not necessarily profit motivated.

Keywords: Evaluation, Organizations, DEA (Data Envelopment Analysis), Performance.

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Information on Efficiency and Productivity Products and Services

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Econometric Methods for Efficiency Measurement, including Stochastic Frontier Analysis Methods:
Saturday 15.1.05, Friday 28.1.05, Friday 4.2.05 and Friday 18.2.05.

Data Envelopment Analysis
Sunday 16.1.05, Saturday 29.1.05, Saturday 5.2.05 and Saturday 19.2.05

The Comparative Use of Econometric and DEA Methods for Performance measurement
Friday 15.4.05, Saturday 16.4.05 , Friday 22.4.05 and Saturday 23.4.05.

Bookings: e.thanassoulis@aston.ac.uk.

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- Ability to handle UNLIMITED numbers of assessment units;
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