SIXTH EUROPEAN WORKSHOP

ON

EFFICIENCY AND PRODUCTIVITY ANALYSIS

Copenhagen, Denmark, October 29-31, 1999

Preliminary program:

Friday 29/10/99 - 12.00 – 13.00

Registration

Session 1 - Friday 29/10/99 - 13.00 – 15.45

Opening session

Chairman P. Bogetoft

1. THE EVOLUTION OF DEA - ECONOMICS AND OPERATIONS RESEARCH PERSPECTIVES

   F. Førsund
   L. Seiford

2. EFFICIENCY AND PRODUCTIVITY STUDIES IN INCENTIVE REGULATION OF UK UTILITIES

   C. Waddams Price

3. USING DEA TO REGULATE NORWEGIAN ELECTRICITY DISTRUBUTION UTILITIES

   S.A.C. Kittelsen

Friday 29/10/99 - 15.45 – 16.15

Coffee Break

Session 2 - Friday 29/10/99 - 16.15 – 18.00

2A. Statistical foundation 1

Chairman and discussant: J. Pastor

1. EVALUATING CONTEXTUAL VARIABLES AFFECTING PRODUCTIVITY USING DATA ENVELOPMENT ANALYSIS

   R. D. Banker
   R. Natarajan

2. THE ANALYSIS OF TECHNICAL EFFICIENCY: SOME STATISTICAL CONSIDERATIONS

   C. Arias

3. TESTING RESTRICTIONS IN NONPARAMETRIC EFFICIENCY MODELS

   P. W. Wilson
   L. Simar

2B. Banking

Chairman and discussant: H. Fried

1. PRODUCTIVITY CHANGE IN SWEDISH BANKS: A COMPARISON OF MALMQUIST PRODUCTIVITY INDEXES

   A.P. Mlima

2. BENCHMARK DEA WITH AN APPLICATION TO FORTUNE GLOBAL 500 BANKS

   A.I. Ali
   Y. Chen

3. TECHNOLOGY AND ENVIRONMENTAL DIFFERENCES IN THE EUROPEAN BANKS: AN HOMOTHETIC DISTANCE FUNCTION APPROACH

   M.E. Chaiffai
   M. Dietsch
   A. Lozano-Vivas

2C. Environmental efficiency

Chairman and discussant: S. Grosskopf

1. SOURCES OF PRODUCTIVITY GROWTH AND ENVIRONMENTAL POLLUTION: A PARAMETRIC APPROACH

   G. Karagiannis
   A. Xepapadeas

2. ADAPTING NONRADIAL DEA METHODS TO IDENTIFY THE TECHNICAL EFFICIENT 'LEAST POLLUTING' FRONTIER

   B. Shankar
   D. Haley

3. ANALYSIS OF ENVIRONMENTAL EFFICIENCY VARIATION

   S. Reinhard
   C.A. Knox Lovell
   G. Thijssen

Friday 29/10/99 - 19.00 – 20.00

Welcome reception at Hotel Kong Arthur

Session 3 - Saturday 30/10/99 - 9.00 – 10.45

3A. Statistical foundation 2

Chairman and discussant: L. Simar

1. DISTRIBUTION ON SCALE OF OPERATION AND EFFICIENCY ESTIMATES IN DEA

   A. Giuffrida
   P. C. Smith

2. A MONTE CARLO STUDY ON THE TECHNICAL EFFICIENCY ESTIMATION IN THE STOCHASTIC FRONTIER MODEL

   R. Dios
   A. Ramos

3. AN EMPIRICAL COMPARISON OF BAYESIAN AND CLASSICAL APPRAOCHES TO INFERENCE ON EFFICIENCY LEVELS IN STOCHASTIC FRONTIER MODELS WITH PANEL DATA

   Y. Kim
   P. Schmidt

3B. Non-convexity

Chairman and discussant: N. C. Petersen

1. POLARITY IN DEA ON RELAXED CONVEXITY ASSUMPTIONS

   P. Agrell
   P. Bogetoft
   J. Tind

2. MEASURING CONGESTION WITH CONVEX AND NON-CONVEX TECHNOLOGIES: DEFINITION, MEASURES, TESTS AND EMPIRICAL ILLUSTRATION

   K. Kerstens
   P. Vanden Eeckaut

3. ESTIMATING NON-CONVEX PRODUCTION SETS USING TRANSCONVEX DEA

   T. Post

3C. Public sector applications

Chairman and discussant: J. L. Hougaard

1. ENHANCING THE PERFORMANCE OF RURAL COUNTRIES

   H. O. Fried
   J. D. Klein

2. SOME TECHNIQUES TO IDENTIFY RETURNS TO SCALE: AN APPLICATION TO THE BRAZILIAN PUBLIC SECTOR

   F. S. Ramos
   M. da C.S. de Sousa

3. ON THE DETERMINANTS OF SCHOOL DISTRICT EFFICIENCY: COMPETITION AND THE COSTS OF MONITORING

   S. Grosskopf et al.

Saturday 30/10/99 - 10.45 – 11.15

Coffee Break

Session 4 - Saturday 30/10/99 - 11.15 – 13.00

4A. Sensitivity analysis in DEA

Chairman and discussant: W.W.Cooper

1. A NOTE ON THE THOMPSON-THRALL ET AL. MULTIPLIER APPROACH TO SENSITIVITY ANALYSIS

   W.W. Cooper
   S. Li
   R. Thrall

2. EVALUATION OF ROBUSTNESS OF DECISION MAKING UNIT USING DUAL MULTIPLIERS

   V. Boljuncic
   L. Neralic

3. SENSITIVITY ANALYSIS OF RETURNS TO SCALE CLASSIFICATIONS IN DEA

   L. M. Seiford
   J. Zhu

4B. SFA applications to agriculture

Chairman and discussant: T. Coelli

1. SOIL SPECIFIC TECHNICAL AND MINERAL INPUT FACTOR EFFICIENCIES IN CEREAL PRODUCTION IN FINLAND

   S. Bäckman
   A. Oude Lansink

2. FARM TECHNICAL EFFICIENCY AND EXTENSION

   S. O'Neill
   A. Matthews

3. TECHNICAL CHANGE AND PRODUCTIVE INEFFICIENCY CHANGE IN NORWEGIAN SALMON FARMING

   R. Tveterås
   G. E. Battese

4C. Organization

Chairman and discussant: P. Bogetoft

1. DEA BASED R&D INFRASTRUCTURE GRANT PROPOSAL SCREENING METHODOLOGY: FILTERING INFERIOR PROPOSALS USING INVERSE DEA AND INVERSE CROSS EFFICIENCIES

   J. Ruggieri
   J. C. Paradi

2. EXECUTIVE COMPENSATION, BOARD INFLUENCE, AND FIRM EFFICIENCY: DUTCH EXPERIENCE

   I. Hasan
   D. Imam
   R. Kabir

3. AN APPROACH TO PERFORMANCE BASED BUDGETING: BEHAVIOUR VS. STATUS

   J. E. Storbeck

Saturday 30/10/99 - 13.00 – 14.00

Lunch

Session 5 - Saturday 30/10/99 - 14.00 – 15.45

5A. Health efficiency

Chairman and discussant: O. Olsen

1. ON THE CAUSALITY BETWEEN GDP AND HEALTH CARE EXPENDITURE IN AUGMENTED SOLOW GROWTH MODELS

   A. Heshmati

2. TESTING DEA MODELS OF EFFICIENCY IN NORWEGIAN PSYCHIATRIC OUTPATIENTS CLINICS

   S. A.C. Kittelsen
   J. Magnussen

3. THE IMPACT OF HEALTH CARE FINANCING REFORM ON THE PRODUCTIVITY CHANGE IN FINNISH HOSPITALS

   M. Linna

5B. New efficiency measures

Chairman and discussant: W.W. Cooper

1. A NEW EFFICIENCY MEASURE CONSISTENT FOR AGGREGATION

   B. Dervaux
   H. Leleu

2. ALLOCATIVE EFFICIENCY OF TECHNICALLY INEFFICIENT PRODUCTION UNITS

   P. Bogetoft
   R. Färe

3. DETERMINING THE BEST EFFICIENCY EVALUATION OF A SET OF UNITS

   J. T. Pastor

5C. Value and goal models

Chairman and discussant: P. Agrell

1. RESTRICTING WEIGHTS IN VALUE EFFICIENCY ANALYSIS

   M. Halme
   P. Korhonen

2. MEASURING AND EVALUATING EFFICIENCY AND EFFECTIVENESS USING GOAL PROGRAMMING
AND DATA ENVELOPMENT ANALYSIS IN A FUZZY ENVIRONMENT

N. Sheth
K. Triantis

3. A GOAL PERSPECTIVE OF DEA

W.B. Liu
J.A. Sharp

Saturday 30/10/99 - 15.45 – 16.45

Coffee Break

Session 6 - Saturday 30/10/99 - 15.45 – 16.45

6A. Software session

Chairman and discussant: P. Vanden Eeckaut

6B. Poster session

Chairman: M. Asmild

Hospital/medical

1. OWNERSHIP, CASE MIX HETEROGENITY AND HOSPITAL OWNERSHIP

R. Adams
S. Alam
G. Granderson

2. PRODUCTIVITY OF MEDICAL STAFF

M. Dlouhý

3. EXPLAINING THE EFFICIENCY PATTERN OF HOSPITALS DIAGNOSTIC TECHNOLOGIES:
A MULTILEVEL ANALYSIS

C.E. Dismuke
V. Sena

Bootstrap and statistics

1. A BOOTSTRAP ANALYSIS OF TECHNICAL, EFFICIENCY AND PRODUCTIVITY CHANGES IN SPANISH AIRPORTS USING THE MALMQUIST INDEX

C. Murillo-Melchor

2. BOOTSTRAPPING DEA-AR EFFICIENCY SCORES

   T. Beltov

3. NONPARAMETRIC EFFICIENCY MEASUREMENT USING AGGREGATE DATA: A MONTE CARLO SIMULATION TO EVALUATE THE BIAS IN RANKING

   B. Brümmer
   H. Thiele

Transportation

1. PARAMETRIC DEA ANALYSES OF AIRLINE MARKETING INVESTMENTS

   S. Andersson

2. THE ALLOCATIVE INEFFICIENCY AND ITS COST IN SPANISH RAILWAYS

   J.B. Pino
   V.F. Blanco
   A.R. Álvarez

3. EFFICIENCY, PRODUCTIVITY AND RETURNS TO SCALE IN A PRIVATISED RAIL INDUSTRY: THE CASE OF GREAT BRITAIN

   J. Cowie

Theory

1. A SHADOW PRICE APPROACH TO TECHNICAL EFFICIENCY MEASUREMENT

   L. Cherchye

2. SOME MODELS FOR MEASURING (SUPER-)EFFICIENCY OUTWITH THE VRS CONVEX HULL

   I. Paterson

3. DATA ENVELOPMENT ANYLYSIS OF NON-CONVEX TECHNOLOGY: WITH AN APPLICATION TO FINNISH SUPER LEAGUE PESIS PLAYERS

   T. Kuosmanen

Banks

1. CREDIT RISK AND EFFICIENCY IN THE EUROPEAN BANKING SYSTEMS: A THREE-STAGE ANALYSIS

   J.M. Pastor

2. DEREGULATION AND CONSOLIDATION IN THE SPANISH INSURANCE INDUSTRY: EFFICIENCY EFFECTS

   J.D. Cummins
   M. Rubio-Misas

3. THE RELATIONSHIP BETWEEN COST AND PROFIT EFFICIENCY IN THE FRENCH BANKING INDUSTRY SINCE 1993

   O. Burkart
   M. Dietsch

Session 7 - Saturday 30/10/99 - 16.45 – 18.30

7A. Hospitals

Chairman and discussant: P. Wilson

1. A FRAMEWORK FOR ASSESSING MEDICAL TREATMENT AT THE PROCEDURAL LEVEL

   H. O. Fried et. al

2. MODELING ECONOMIC BEHAVIOR IN DEA-SETTING: THE CASE OF DUTCH GENERAL HOSPITALS

   E. Eggink
   J.L.T. Blank

3. DO HOSPITAL MERGERS RESULT IN IMPROVED SCALE EFFICIENCY?

   G. Ferrier
   V. Valdmanis

7B. Comparisons in agriculture

Chairman and discussant: S. Stefanou

1. INTERNATIONAL TRADE, COMPETITIVENESS, AND PRODUCTIVITY

   L.E. Fulginiti

2. TECHNICAL, ALLOCATIVE AND ECONOMIC EFFICIENCY OF FARMS IN BANGLADESH: A COMPARISON OF ECONOMETRIC AND MATHEMATICAL PROGRAMMING METHODS

   M. A. Wadud

3. COMPARISON OF INDEX, NONPARAMETRIC AND PARAMETRIC PRODUCTIVITY MEASURES: NEBRASKA AGRICULTURE SECTOR

   S. Shaik
   R.K. Perrin

7C. Weights

Chairman and discussant: P. Korhonen

1. IMPROVING ENVELOPMENT IN DATA ENVELOPMENT ANALYSIS

   R. Allen
   E. Thanassoulis

2. THE EFFICIENCY OF PUBLIC FORESTRY ORGANISATIONS:
   A COMPARISON OF DIFFERENT WEIGHT RESTRICTION APPROACHES

   T. Joro
   E.J. Viitala

3. DEA MODELS WITH NON-HOMOGENEOUS WEIGHT RESTRICTIONS

   V. Podinovski

Saturday 30/10/99 - 20.00 –

Workshop Dinner

Session 8 - Sunday 31/10/99 - 9.00 – 10.45

8A. Malmquist

Chairman and Discussant: E. Grifell-Tatjé

1. YET ANOTHER MALMQUIST PRODUCTIVITY INDEX DECOMPOSITION

   J.L. Zofio
   C.A.Knox Lovell

2. BIAS IN MALMQUIST INDEX AND COST FUNCTION PRODUCTIVITY MEASUREMENT (AND HOW TO CORRECT IT)

   A. L. Vivas
   D. B. Humphrey

3. IMPLICIT VALUE SHARES IN MALMQUIST TFP INDEX NUMBERS

   T. Coelli
   D.S. Prasada Rao

8B. Statistical foundation 3

Chairman and discussant: G.E.Battese

1. ESTIMATION OF MONOTONE AND CONCAVE OR CONVEX FUNCTIONS

   R. D. Banker
   S. Janakiraman
   R. Natarajan

2. ASSESSING MODELS IN FRONTIER ANALYSIS THROUGH DYNAMIC GRAPHICS

   G.C. Porzio
   S. Destefanis

3. STATISTICAL TESTS OF ALLOCATIVE EFFICIENCY USING DEA: AN APPLICATION TO THE U.S. PUBLIC ACCOUNTING INDUSTRY

   R.D. Banker
   H. Chang
   R. Natarajan

8C. Manufacturing application

Chairman and discussant: K.Triantis

1. AUTOMOBILE PRODUCTION: A SHIFT TOWARD LEANER, MORE EFFICIENT ASSEMBLY

   S. Yaisawarng
   E. DeKoven

2. FACTORS OF PERFORMANCE OF DAILY NEWSPAPER COMPANIES IN FRANCE

   P.Y. Badillo
   N. Romain

3. FIRM SIZE, AGE AND EFFICIENCY: EVEDENCE FROM KENYAN MANUFACTURING FIRMS

   K. Lundvall
   G. E. Battese

Sunday 31/10/99 - 10.45 – 11.15

Coffee Break

Session 9 - Sunday 31/10/99 - 11.15 – 13.00

9A. Productivity

Chairman and discussant: L. Hjalmarsson

1. PRODUCTIVITY GROWTH IN THE SPANISH DAIRY FARMS: A PARAMETRIC APPROACH

   R. A. Cuesta
   L. Orea

2. PARAMETRIC AND NON-PARAMETRIC MODELS OF TOTAL FACTOR PRODUCTIVITY'S CONVERGENCE

   F.J. Arcelus
   P. Aracena

3. DECOMPOSING PRODUCTIVITY GROWTH ALLOWING EFFICIENCY GAINS AND TECHNICAL PROGRESS

   A.O. Lansink
   E.Silva
   S.Stefanou

9B. Size and scale

Chairman and discussant: R. Banker

1. SCALE EFFICIENCY AND PRODUCTIVITY CHANGE

   B. M. Balk

2. TECHNICAL EFFICIENCY, MANAGEMENT AND ECONOMIES OF SIZE

   A. Alvarez

3. ESTIMATION OF ELASTICITIES OF SUBSTITUTION AND SCALE BY DEA

   O. Olesen
   N. C. Petersen

9C. Electricity application

Chairman and discussant: S.A.C Kittelsen

1. USING AN IDEAL NETWORK IN THE STUDY OF THE ELECTRICITY DISTRIBUTION COST IN SPAIN

   E. Grifell-Tatjé
   C.A. Knox Lovell

2. EFFICIENCY AND INCENTIVES IN REGULATED INDUSTRIES: THE CASE OF ELECTRICITY DISTRIBUTION IN SCANDINAVIA

   P.J. Agrell
   P. Bogetoft
   J. Tind

3. TECHNICAL EFFICIENCY OF FINNISH ELECTRICITY DISTRIBUTION SECTOR

   P. Sulamaa

Sunday 31/10/99 - 13.00 – 14.00

Lunch

Session 10 - Sunday 31/10/99 - 14.00-16.00

10A. SFA

Chairman and discussant: G.E. Battese

1. PRODUCTION RISK, RISK PREFERENCES, AND FIRM-HETEROGENEITY: A JOINT ANALYSIS

   S.C. Kumbhakar
   R. Tveterås

2. SPATIAL ANALYSIS OF STOCHASTIC FRONTIER MODELS

   V. Druska
   W.C. Horrace

3. DETERMINANTS OF MUTUAL FUND PERFORMANCE: A BAYESIAN STOCHASTIC FRONTIER APPROACH

   J. Annaert
   R. Vander Vennet
   J. van den Broeck

10B. New applications

Chairman and discussant: L.Seiford

1. FRONTIER ANALYSIS AND EFFICIENCY OF LABOUR MARKETS IN MAROKKO

   A. Ibourk
   S. Perelman

2. A GROUP DECISION MAKING METHOD FOR THE CAPITAL RELOCATION PROJECT OF JAPAN

   K. Tone

3. ELECTRICITY IN AFRICA AND PRODUCTIVE PERFORMANCE: AN ASSESSMENT USING PRODUCTION FRONTIERS

   L. Hofman
   P. Plane

4. USING FRONTIER EFFICIENCY MODELS AS A TOOL TO RE-ENGINEER NETWORKS OF PUBLIC SECTOR BRANCHES:
   AN APPLICATION TO THE HELLENIC TOBACCO ORGANIZATION

   A. D. Athanassopolous

10C. Efficiency theory

Chairman and discussant: R. Färe

1. PAIR-WISE DOMINANCE AND THE RANKING OF FUZZY PRODUCTION PLANS

   S. Sarangi
   K. Triantis
   D. Kuchta

2. BENCHMARK SELECTION: AN AXIOMATIC APPROACH

   J.L. Hougaard
   M. Tvede

3. A DEFINITION OF THE "PRACTICAL FRONTIER" IN DEA

   T. Sowlati
   J.C. Paradi

4. A DIFFERENTIAL DECOMPOSITION OF PROFIT EFFICIENCY: AN APPLICATION TO U.S. BANKS

   S.C. Ray
   S.M. Miller
   K. Mukherjee

Sunday 31/10/99 - 16.00 – 17.00

Coffee Break

11A. Software session

Chairman and discussant: P. Vanden Eeckaut

11B. Poster session

Chairman: M. Asmild

Education

1. INCLUDING NON-DISCRETIONAL INPUTS IN DEA ANALYSIS. AN APPLICATION TO SPANISH PUBLIC EDUCATION

   M. A. Muñiz-Pérez
   J. Suárez-Pandiello

2. DEA FOR POISSON COUNT OUTPUTS

   J. M. Alho
   T. J. Räty

3. A FUZZY MODEL TO EVALUATE PRODUCTIVITY AND QUALITY OF ACADEMIC DEPARTMENTS

   A.L.M. Lopes
   E. A. Lanzer
   R.M. Barcia

Theory

1. CONTINUITY OF DEA EFFICIENCY SCORES

   H. Scheel

2. THE ESTIMATION OF THE SHADOW COST MODEL WITH SPACE AND TIME-VARYING INPUT PRICE DISTORTIONS

   O. W. Maietta

3. A NON-DIRECTIONAL MEASURE OF TECHNICAL EFFICIENCY

   D. Roibás

4. TRADE RESTRICTIVENESS AND EFFICIENCY

   N.H. Chou
   R. Färe
   S. Grosskopf

Agriculture

1. PERFORMANCE OF DAIRY PLANTS IN THE COOPERATIVE AND PRIVATE SECTOR IN INDIA

   S. Singh
   T. Coelli

2. A VARIABLE DIVIDEND EFFICIENCY EFFECTS MODEL OF THE COFFEE PROCESSING SECTOR IN COSTA RICA

   R. Mosheim

3. INTERRELATION OF EFFICIENCY, PRODUCTIVITY AND PROFITABILITY – AN APPLICATION ON FINNISH BOOKKEEPING GRAIN FARMS

   T. Sipiläinen

4. PRODUCTION FUNCTIONS WITH ASSYMMETRIC MEASUREMENT ERROR IN INPUTS: ACCOUNTING FOR LABOR OVER-REPORTING IN UKRAINE'S COLLECTIVE FARMS

   L.A. Kurkalova
   A. Carriquiry

Productivity

1. NONPARAMETRIC CONTINUOUS TIME PRODUCTIVITY MEASUREMENT BASED ON DISCRETE DATA

   E. Belsom

2. AN ANALYSIS OF PRODUCTIVITY IN IRAN

   S. Amirian
   N. Nafar
   T. Modares

3. COST EFFICIENCY OF JAPANESE ELECTRIC UTILITIES BEFORE AND AFTER REGULATORY REFORMS IN 1995

   T. Hattori

4. PRODUCTIVITY, R&D CAPITAL, AND PUBLIC INNOVATION SUPPORT; THE CASE OF DANISH MANUFACTURING

   M. Marcusson
   A. Sørensen

Session 12 - Sunday 31/10/99 - 17.00 – 18.00

New developments

Chairman and discussant: C.A. Knox Lovell

PANEL DISCUSSION WITH SCIENTIFIC COMMITTEE

Sunday 31/10/99 - 18.00 – 19.00

Farewell reception at KVL

SIXTH EUROPEAN WORKSHOP

ON

EFFICIENCY AND PRODUCTIVITY ANALYSIS

Copenhagen, Denmark, October 29-31, 1999

Book of abstracts

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Session 1 - Friday 29/10/99 - 13.00 – 15.45
Opening session

THE EVOLUTION OF DEA – THE ECONOMICS PERSPECTIVE

Finn R. Førsund, Department of Economics, University of Oslo, Norway

The richness of ideas presented in Farrell's seminal 1957 paper is demonstrated by the fact that the developments in the following three decades were based on aspects and ideas there. But it is rather remarkable that this is not recognised fully in the key papers following up the research. The origins of the main developments are identified, and the connection to the OR literature on DEA is explored.

STEPPING BACK AND LOOKING FORWARD - DATA ENVELOPMENT ANALYSIS FROM AN OPERATIONS RESEARCH PERSPECTIVE

Lawrence M. Seiford, Mechanical & Industrial Engineering, University of Massachusetts, Amherst
and National Science Foundation, Washington, DC

The seminal paper of Charnes, Cooper and Rhodes (1978) was published twenty years after Farrell (1957). We take this CCR paper as our starting point, briefly describe the antecedents, and trace the historical development of Data Envelopment Analysis over the past 20 years from the perspective of the Operations Research/Management Science community. The conclusion is that DEA has become a widespread and important analytical tool used for far more than estimating productive efficiency.

EFFICIENCY AND PRODUCTIVITY STUDIES IN INCENTIVE REGULATION OF UK UTILITIES

Catherine Waddams Price, Centre for Management under Regulation, University of Warwick, UK

The reform of the UK utilities over the last fifteen years has laid considerable emphasis on the incentive properties both of private ownership and the regulation of the privatised industries which has followed. This paper reviews the arguments for such a policy, and describes the use of efficiency and productivity studies, both in undertaking the regulation itself and in assessing its effectiveness. The establishment of separate industry specific regulators has resulted in a considerable variety of approach, and the assessment of the outcome also provides a rather mixed result, both with respect to the impact and its timing.

USING DEA TO REGULATE NORWEGIAN ELECTRICITY DISTRUBUTION UTILITIES

Sverre A.C. Kittelsen, Ragnar Frisch Centre for Economic Research, Oslo, Norway

This paper examines the theoretical and practical possibilities and problems in using yardstick competition based on cost information from the Data Envelopment Analysis (DEA) method. The incentive structure of public utilities is reviewed, as are the different alternatives available to the regulator. The paper discusses the information required in a price cap regime, and whether the DEA method can supply this information. Potential limitations of the approach are also discussed, notably the incentive to reduce quality inherent in price cap regimes and the dynamic problem of inducing the best practice firms to become even more efficient.

These questions are illustrated with experience from the regulation of Norwegian Electricity Distribution Utilities (EDUs), which from 1999 is mainly a price cap regime based on DEA. Empirical results are presented for the measurement of efficiency, costs and optimal prices, and comparisons are made to actual pre-regulation prices. Statistical tests are used to determine which product aspects should be included in the cost function. While there is no tendency for the EDUs to reap monopoly profits for their owners, there is evidence of potential efficiency gains of up to 25% of total turnover.

Session 2 - Friday 29/10/99 - 16.15 – 18.00
2A. Statistical foundation 1

EVALUATING CONTEXTUAL VARIABLES AFFECTING PRODUCTIVITY USING DATA ENVELOPMENT ANALYSIS

R. D. Banker, School of Management, The University of Texas at Dallas, Richardson, USA
R. Natarajan, School of Management, The University of Texas at Dallas, Richardson, USA

Many studies have assessed the impact of contextual factors on Data Envelopment Analysis (DEA) efficiency scores (Grosskopf 1996). In these studies, the relative efficiency of each organization is evaluated in the first stage based on data about their input consumption and output production. The efficiency score is then regressed on the potential contextual factors in the second stage to identify the factors whose impact on productivity is statistically significant. Alternative second stage methods have included the use of logarithmic transform of the relative efficiency score as dependent variable in an Ordinary Least Squares regression, and the use of a TOBIT (Tobin's Censored Regression Model 1958) procedure to reflect the fact that the logarithm of the DEA efficiency score is bounded above by zero.

A question that has not been addressed in earlier studies is whether such a two-stage approach is statistically valid for assessing the significance of individual contextual variables. We present here a rigorous analysis of this issue. We first specify the basic data generating process in terms of the true production function, and random variables representing the inputs and productivity. A key feature of the data generating process is that the random variable representing productivity itself consists of three components, a function of the contextual variables, a one-sided inefficiency term and a two-sided random noise term bounded above. We then develop a DEA based estimation procedure that is consistent with the data generating process by adapting the DEA+ method introduced by Gstach (1998).

We present parametric and nonparametric methods that can be used to compute statistically consistent estimators of the impact of the contextual variables on the DEA efficiency scores. For the parametric method, we also present estimators of the inefficiency of individual DMUs conditional on the estimated value of the composite error comprising the one-sided inefficiency component and the two-sided random noise component. We show that using DEA in the first stage followed by OLS in the second stage leads to consistent estimation of the impact of contextual variables. In contrast, MLE does not always provide consistent estimates. We also describe the statistical validity of alternative procedures that apply DEA in the second or later stages to make inferences about how contextual variables affect productivity. Finally, we present the results of Monte Carlo experiments designed to evaluate the performance of alternative estimation procedures.

NONPARAMETRIC EFFICIENCY MEASUREMENT USING AGGREGATE DATA: A MONTE CARLO SIMULATION TO EVALUATE THE BIAS IN RANKING

B. Brümmer, Institute of Agricultural Economics, Christian-Albrechts-University Kiel, Germany
H. Thiele, University of Giessen, Germany

This paper employs Monte Carlo experimentation to investigate the consequences of using aggregate data for efficiency analysis. Several applications utilized aggregate data to measure either cross country productivity differentials (Chambers, Färe, and Grosskopf 1996; Färe, Grosskopf, Norris, and Zhang 1994; Fulginiti and Perrin 1997) or to evaluate sectoral productivity within a country (Färe, Grosskopf, and Lee 1995). Mainly, these studies used Data Envelopment Analysis (DEA); therefore, we restrict our attention to DEA. Although the concept of efficiency measurement is theoretically well founded at the level of individual observations, it is not clear if there is any penalty involved when using efficiency analysis methods, e.g. DEA, with aggregate data. The first thing to note is that aggregation reduces the number of observations in the sample. Previous studies have shown that the number of firms in an industry plays an important role for the determination of the average efficiency (Zhang and Bartels, 1998). This specific problem is not that severe if the researcher is only interested in relative differences in efficiency, i.e. the ranking of the groups. Further problems that might affect not only the average efficiency but also the ranking could arise from different sources: The distribution of inefficiencies might be heteroscedastic, the number of firms within each group might be different, the aggregation criteria might introduce systematic bias, and issues related to multidimensionality , i.e. the number of in- and outputs in the analysis, might occur. To check for the above mentioned factors, we test the reliability with which the individual data as well as the aggregate data will yield similar efficiency rankings by group. Preliminary Monte Carlo simulation results from an output-orientated single output model indicate that DEA based on aggregate data will lead to a substantially biased estimate of average efficiency, and to an efficiency ranking that is at least partly unreliable. Especially, heteroscedastic efficiency distributions and heterogeneity regarding the group sizes seem to alter the ranking considerably. Finally, corrections that can be used to take different levels of aggregation into account will be explored.

TESTING RESTRICTIONS IN NONPARAMETRIC EFFICIENCY MODELS

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This paper discusses statistical procedures for testing various restrictions in the context of nonparametric models of technical efficiency. In particular, tests for whether inputs or outputs are irrelevant, as well as tests of whether inputs or outputs may be aggregated are formulated. Bootstrap estimation procedures which yield appropriate critical values for the test statistics are also provided. Evidence on the true sizes and power of the proposed tests is obtained from Monte Carlo experiments.

Session 2 - Friday 29/10/99 - 16.15 – 18.00
2B. Banking

BIAS IN MALMQUIST INDEX AND COST FUNCTION PRODUCTIVITY MEASUREMENT (AND HOW TO CORRECT IT)

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Many current Malmquist Index studies of banking industry productivity are biased, typically overstating the rate of productivity advance. A similar bias exists for banking productivity estimated with a stochastic frontier cost function or a growth accounting approach. The bias is not due to the technique used but rather in how it is applied. While the bias is easiest to see in banking industry studies, due the nature of the data available to represent outputs and inputs, it can exist in other industries as well. The bias is simple to correct and can easily be reduced or eliminated in future analyses.

We demonstrate that the majority of measured productivity change in many existing studies is due to this bias and thus does not reflect "true" productivity advance. Additionally, we apply three methods of measuring productivity change to panel data on the Spanish banking system over 1986-1991. Our purpose is to illustrate how mean productivity estimates are reduced as more and more of the bias is eliminated. We also show how productivity estimates are affected by the bias over time and across banks within the panel data set. Since the true value of productivity is unknown, it is not possible to identify one of the three different methodologies as being closest to being correct. However, given the different results obtained using each method, this clearly is a task worthy of further research and analysis.

BENCHMARK DEA WITH AN APPLICATION TO FORTUNE GLOBAL 500 BANKS

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The methodology of DEA is applied for evaluating the performance of a set of practices relatives to a known benchmark set of exemplary practices. Such a benchmarking framework, which requires a non-traditional application of existing DEA methodology, is presented in the context of constant-returns-to-scale, inputs-oriented, DEA models. The paper introduces a modified DEA model that allows computation of a performance score defined to be the average proportionate change in inputs. This score is a refinement of the typically used score which represents the maximum over proportionate changes for inputs. The model is applied to evaluate the performance of the 1995 Fortune Global 500 banks with respect to a benchmark set consisting of U.S. and U.K. banks.

TECHNOLOGY AND ENVIRONMENTAL DIFFERENCES IN THE EUROPEAN BANKS: AN HOMOTHETIC DISTANCE FUNCTION APPROACH

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To know how different or similar current banking performances are in different countries, two main aspects have to be considered: (i) how different the underlying banking technologies are among country banking industries and; (ii) which particular environmental and regulatory conditions characterize the market where

each banking industry is operating. However, most of the intercountry banking comparison studies which exist in the literature measure productive differences among countries without taking into account one or both of the aspects pointed out above. Actually, in the literature only one intercountry banking comparison paper exists which takes into account technology differences between countries (Pastor et al. (1997)). In that paper, a decomposition of differences in productivity into inefficiency and technology differences between countries is proposed. To do that, the authors define a Malmquist productivity index that is asymmetric because it depends of which county is chosen as the reference for the comparison. Moreover, the results obtained in this paper show large differences between country frontiers, which could not be attributed to pure technology differences but it likely comes from demand characteristic conditions, regulation differences, accessibility of banking services, and other particular environmental differences in which each banking industry is working. Recently, Dietsch and Lozano-Vivas (1996) and Lozano-Vivas, Pastor and Pastor. (1997) show that efficiency differences are strongly explained by country-specific differences (almost always excluded from cost and efficiency analysis). Moreover, these authors conclude that the integration of environmental variables into the intercountry comparison analysis allows researchers to measure properly efficiency differences between countries. In the present paper we attempt to contribute to the intercountry banking comparison literature proposing a methodology which permits to decompose the performance differences between country banking industries into pure technology differences and differences due to country environmental effects. To do that we define a Malmquist type index which permits us to decompose properly the differences between country frontiers into two components. The first component is dealing with the pure technology differences and the second component reflects the environmental effect, which affect the banking technology of each country. The decomposition of the index is based on homothetic distance functions. Unlike the index proposed by Pastor et al. (1997), the Malmquist index we propose here is symmetric and has the property that it is not sensitive to which country is taken as benchmark reference. We apply our methodology to compare the productivity differences of European banking industries using the econometric approach. We define a parametric distance function and use the stochastic frontier specification in our comparison. We represent the technology in each country by an homothetic translog functional form. Additionally, because the parametric approach is criticized by which functional form is chosen to represent the frontier, we analyze the robustness and the sensitivity of our results defining alternatively the Coob-Douglas functional form. For each country, we estimate the frontier by the within and the generalized least squares methods. Moreover, because the level and quality of service associated with deposits and loans in different countries may differ in ways that are difficult to measure, previously we study deeply the data information. That is, we check for the homogeneity about the output and input information of the different country banking industries under investigation. It permits us to obtain a clearer picture of the topic under investigation.

Session 2 - Friday 29/10/99 - 16.15 – 18.00
2C. Environmental efficiency

SOURCES OF PRODUCTIVITY GROWTH AND ENVIRONMENTAL POLLUTION: A PARAMETRIC APPROACH

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In analyzing the relation between productivity changes and environmental pollution, the possible slowdown effects of environmental regulations, as well as the potential enhancement effects of lack of regulation or insufficient strength of regulation, should be taken into account. Previous studies on measuring TFP changes in the presence of undesirable output have relied on Malmquist productivity index and non-parametric techniques. By doing so, they were unable to account for the potential impact of the weak output

disposability assumption on allocative efficiency and to measure the portion of TFP change that is attributed to the deviation between shadow and market prices (e.g., taxes) of undesirable outputs.

To overcome these limitations, we propose a parametric framework based on duality results between revenue and output distance functions. At a first instance a revenue function is used to develop a decomposition of TFP changes into seven components. These refer to technical change, technical and allocative efficiency, scale economies, a price adjustment effect, and two environmentally related factors. The first of them is associated with taxed undesirable outputs and the second with uncontrolled bads.

These effects can separately be measured by solely relying on the econometric estimation of an output distance function. Then, quantitative measures are obtained by using duality results relating primal (output distance function) and dual (revenue function) measures of the rate of technical change, the degree of technical and allocative inefficiency and of returns to scale. In addition, shadow (revenue deflated) prices, derived through the estimated distance function by making use of Shephard's lemma, are used to obtain measures of the price adjustment and the environmentally related effects.

The proposed framework has exactly the same data requirements as the Malmquist index approach, namely only input and output data are required. Flexible functional forms (e.g., translog) can be used to approximate the underlying output distance function, and single-equation techniques are required for the econometric estimation.

ADAPTING NONRADIAL DEA METHODS TO IDENTIFY THE TECHNICALLY EFFICIENT 'LEAST POLLUTING' FRONTIER

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Nonradial Data Envelopment Analysis methods have been employed whenever there has been a need for a method more capable of discriminating among inputs than the typical radial DEA models. These include applications to agricultural production, where the aim is to investigate the scope for reduction in a subset of inputs that cause pollution, i.e., fertilizers and pesticides. We argue, however, that the typical nonradial input reduction method used in this literature is not completely consistent with their stated focus on maximum-possible reduction of a particular *subset* of inputs. This is because the current method maximizes the simple average of individual input reductions, and thus treats all inputs with equal importance. By placing greater weights on polluting input reduction, the 'least polluting' points on the technically efficient frontier can be identified. To the extent that *any* nonradial input shrinkage guarantees only technical and not allocative efficiency, there is no reason to believe that the currently used method identifies points that represent lower production costs than points on the 'least polluting' frontier. However, since the external costs of the least polluting points are lower, they are more appropriate overall, especially since such research is motivated by interest in the subset of polluting inputs.

We investigate this issue theoretically, and provide an application to a sample of UK cereal farms to illustrate.

THE ROLE OF NONPARAMETRIC ANALYSIS IN ADJUSTING AGRICULTURAL PRODUCTIVITY MEASURES FOR ENVIRONMENTAL IMPACTS

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Since agriculture is potentially an important contributor to environmental degradation, it may be especially important in agriculture to adjusted productivity measures to reflect environmental impacts. While the

empirical difficulty of measuring appropriate environmental variables is in itself a daunting challenge, a similarly vexing problem is that of identifying appropriate weights for these variables, relative to conventional inputs and outputs. While consumer willingness to pay would be the most appropriate concept of value for constructing these weights, production shadow prices are often be more feasible to evaluate, since they may be measured from production-related information alone. This paper provides an empirical comparison and evaluation of some alternative uses of non-parametric productivity analysis for adjusting agricultural productivity measurements for environmental impacts in the state of Nebraska.

A direct non-parametric approach to this problem is to estimate a Färe-Malmquist productivity measure that incorporates environmental variables as bad outputs. A closely-related indirect approach is to evaluate the gradients of the piece-wise technology frontier so estimated, to use in constructing shadow shares to revise a standard Tornquist-Theil productivity index. In this paper we quantify three environmental variables in Nebraska for 1936-1994: excess nitrogen leaching, potential pesticide pollution and wetland losses. We then estimate direct hyperbolic graph measures of productivity gains at various levels of commodity aggregation and, alternatively, use the gradients from these analyses to adjust standard productivity indexes for the shadow shares of the environmental inputs. In general, we find that the direct Färe-Malmquist productivity measures result in very little, if any, measurable productivity gain over the period, whereas the indirect shadow price measures result in productivity gains that are only slightly smaller than traditional measures, and in some cases exceed them.

Session 3 - Saturday 30/10/99 - 9.00 – 10.45
3A. Statistical foundation 2

DISTRIBUTION IN SCALE OF OPERATION AND EFFICIENCY ESTIMATES IN DEA

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Data envelopment analysis (DEA) is widely employed for the evaluation of the productive efficiency of decision making units (DMUs). The CCR model of DEA was developed by Charnes, Cooper and Rhodes. Banker, Charnes and Cooper provided the BCC model of DEA and they showed that the CCR efficiency measure can be regarded as the product of a technical efficiency (BCC efficiency) measure and a scale efficiency measure. It is well known that in a deterministic setting a well-specified DEA model will always overestimate the true efficiency. The purpose of this paper is to examine the bias in the efficiency estimated by CCR and BCC models over the DMUs* scale of operation. We present a formal explanation why the biases of the BCC model are not expected to be uniform across the scale of operation. A simple production process with constant returns to scale is then set up. Simulation models are then used to explore empirically the bias in the efficiency estimated by the DEA models over the scale of operation. The simulations showed that in a simple one input and one output production process, the CCR efficiency estimates do not exhibit any bias over the scale of operation, while the BCC efficiency estimates are biased. The bias, as expected, is not uniform across DMU*s size, with small and larger DMUs showing larger biases. Other phenomena investigated in the simulations are: the distribution of observations over the scale of operation and the number of input in the production process. The paper concludes that using DEA model with inappropriate returns to scale assumption, may produce erroneous inference about the presence of economies of scale in the production process.

ESTIMATION OF MONOTONE AND CONCAVE OR CONVEX FUNCTIONS

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A primary issue in statistical research is the investigation of the relationship between an endogenous (or dependent) variable and a set of exogenous (or independent) variables. Researchers typically examine the relationship by making two major assumptions. The first assumption specifies the functional form that expresses the endogenous variable as a function of the exogenous variables. The second assumption specifies a probability distribution for the residual, the random variable that captures the difference between the actual and the predicted values of the endogenous variable. Based on these two assumptions, procedures such as maximum likelihood estimation (MLE) are used to statistically estimate the relationship. These major assumptions about the functional form and the probability distribution are usually treated as maintained assumptions.

Frequently, the a priori guidance provided to a researcher by theoretical considerations is limited. For instance, in economics and physical sciences, theoretical models may specify that the function linking the endogenous variable to exogenous variables is monotone increasing and concave or convex but do not indicate a particular parametric form for the function. Similarly, while theory may suggest that the distribution of the residual is bounded, it may not provide a specific parametric form. The question we address in this paper is whether it is possible to make any robust statistical inferences about the relationship between the variables while maintaining the minimal structure described above.

We exploit the fact that adding a constant to any monotone increasing and concave function generates a function which is also monotone increasing and concave. It is also the case that the additive transformation ensures that the sensitivities of the two functions to the underlying exogenous variables are identical. We show that adding the upper bound of the residual to the original function enables the residual to be transformed to a variable that takes only positive values. The transformed estimation problem can then be solved through DEA and both the transformed function as well as the residual can be estimated consistently. We extend our results to cases where the prior beliefs specify monotone increasing and convex rather than concave functions. Finally, we develop DEA-based tests to evaluate whether a subset of exogenous variables significantly impacts the endogenous variable and to evaluate whether a particular parametric representation adequately captures the functional relationship between the variables. We calibrate the performance of the various procedures developed here through extensive simulations under a variety of scenarios.

AN EMPIRICAL COMPARISON OF BAYESIAN AND CLASSICAL APPRAOCHES TO INFERENCE ON EFFICIENCY LEVELS IN STOCHASTIC FRONTIER MODELS WITH PANEL DATA

Yangeson Kim
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This paper applies a large number of models to three previously-analyzed data sets, and compares the point estimates and confidence intervals for technical efficiency levels. Classical procedures include multiple comparisons with the best, based on the fixed effects estimates; a univariate version, marginal comparisons with the best; bootstrapping of the fixed effects estimates; and maximum likelihood given a distributional assumption. Bayesian procedures include a Bayesian version of the fixed effects model, and various Bayesian models with informative priors for efficiencies. We find that fixed effects models generally perform poorly; there is a large payoff to distributional assumptions for efficiencies. We do not find much

difference between Bayesian and classical procedures, in the sense that classical MLE based on a distributional assumption for efficiencies gives results that are rather similar to a Bayesian analysis with the corresponding prior.

Session 3 - Saturday 30/10/99 - 9.00 – 10.45
3B. Non-convexity

POLARITY IN DEA ON RELAXED CONVEXITY ASSUMPTIONS

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J. Tind, University of Copenhagen, Denmark

This presentation discusses DEA-models under relaxed convexity conditions. Usually convexity is assumed for the entire production possibility set. Here, convexity is only required for input and output projections of the possibility set. Feasible input-output combinations are studied in the original space as well as in a dual space by means of a polarity correspondence with roots in the blocking and anti-blocking theory developed for the analysis of problems in extremal combinatorics.

MEASURING CONGESTION WITH CONVEX AND NON-CONVEX TECHNOLOGIES: DEFINITION, MEASURES, TESTS AND EMPIRICAL ILLUSTRATION

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P. Vanden Eeckaut, Institut de Statistique, Université Catholique de Louvain, Belgium

The purpose of this paper is to define some new nonparametric deterministic reference technologies capable to detect congestion in production. In particular, we generalise the weakly disposable production models proposed in Färe, Grosskopf and Lovell (1983, 1985) by introducing an alternative disposability axiom. This allows defining both convex and non-convex technologies that envelop the data even tighter. We also elaborate upon the use of radial and non-radial efficiency measures both to detect and measure congestion in a decomposition context (see Färe, Grosskopf and Lovell (1983, 1985)). Furthermore, nonparametric test statistics for testing the congestion hypothesis are indicated in line with Simar and Wilson (1998a,b). Finally, these new technologies and the resulting decomposition into technical efficiency and congestion are empirically illustrated and contrasted with the earlier models.

ESTIMATING NON-CONVEX PRODUCTION SETS USING TRANSCONVEX DEA

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In this paper, we present a variety of Data Envelopment Analysis models for estimating efficiency for non-convex production sets. In contrast to the Banker, Charnes and Cooper (1984) model, these models give statistically consistent estimators for production sets that are non-convex, but do have convex input and/or output sets, as is typically assumed in neo-classical micro-economics. In addition, these models suffer less from finite error than the Full Disposable Hull (Deprins et al., 1984) model. Monte-Carlo simulations suggest that the reduction in estimation error relative to both models can be substantial.

ENHANCING THE PERFORMANCE OF RURAL COUNTRIES

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A high quality of rural life is essential for the agricultural sector to attract and retain bright, creative and capable people who will implement the latest innovations and farm in harmony with the environment. Population has been shifting from rural to urban areas for decades as farm productivity has risen dramatically, outpaced growth in demand and depressed the relative price of agricultural products. Urban alternatives have become more attractive; families move and small rural towns and communities decline. Much of this is the market at work. However, the impact on rural communities and towns is uneven and is not completely explained by differences in regional economic forces. There is an endogenous element; some rural areas are able to maintain a high quality of life and thrive as a result of specific actions by local governments and community organizing efforts. It is important to understand successful local initiatives by rural communities, particularly the interactions between local parameters and local actions, in order to enable policies that work in one community to produce similar vitality elsewhere. This paper uses data envelopment analysis to evaluate the performance of 764 rural counties in the U.S. A rural county transforms given resources and external circumstances into a multi-dimensional attribute, economic vitality. Resources and economic circumstances are measured by climate, access to urban areas, education, healthcare, and public safety. Economic vitality is measured by retail activity, incomes and the quality of community life. Some rural communities are more successful in transforming resources into economic vitality than others. Efficiency scores are calculated for all rural counties in the Midwest. For inefficient counties, efficient role model counties are identified. These efficient role model counties have a similar set of resources and exogenous circumstances and are able to provide a more vital environment for their residents. How are they able to do it? Perhaps the explanation lies in creative economic development efforts, the configuration of local taxes and incentives, the structure of local governments, the political will of the community, local government management practices and so on. However, the explanation is not more favorable circumstances or resources to work with, since the model controls for these factors. There is potential for inefficient counties to use this information to improve their performance.

SOME TECHNIQUES TO IDENTIFY RETURNS TO SCALE: AN APPLICATION TO THE BRAZILIAN PUBLIC SECTOR

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The identification of returns to scale in the case of services and goods supplied by municipalities - as education and health - can supply insights on the optimal size of a municipal district. A variety of techniques have been proposed to detect the presence of returns to scale in models DEA. For example, those proposed by Banker (1984), Banker, Charnes and Cooper (1984), Färe, Grosskopf and Lovell (1985), Lothgren and Tambour (1996), Färe (1997), Golany and Yu (1997), Li (1998). In this work, we i) have a survey of the literature on returns to scale using the methodology DEA; ii) use a database of 4.000 observations on the Brazilian municipal districts to calculate returns to scale using several techniques; iii) made an analysis of sensibility of these techniques with base in the referred database. Results show that, in spite of some divergences, the several measures point in the sense of existence of increasing returns to scale for the small municipal districts, with population below 5.000 inhabitants.

ON THE DETERMINANTS OF SCHOOL DISTRICT EFFICIENCY: COMPETITION AND THE COSTS OF MONITORING

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W. L. Weber, Southeast Missouri State University, USA

A substantial literature indicates that the public school system in the United States is inefficient. Some have posited that this inefficiency arises from a lack of competition in the education market. On the other hand, the Tiebout hypothesis suggests that public schools may already face significant competition. In this paper, the authors examine the extent to which competition for student influences public school inefficiency in Texas. We use a Shephard input distance function to model educational production and use bootstrapping techniques to examine allocative inefficiencies. Switching regressions estimation allow us to determine the degree to which inefficiency varies according to concentration/competition.

Session 4 - Saturday 30/10/99 - 11.15 – 13.00
4A. Sensitivity analysis in DEA

SENSITIVITY AND STABILITY ANALYSIS IN DEA: SOME RECENT DEVELOPMENTS

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R.G. Thompson and R.M. Thrall and their associates have developed an approach to sensitivity analysis in which all data, for all DMUs, are varied simultaneously. This is continued until a first change in classification occurs--from efficient to inefficient status (or vice versa). This approach is based on uses of multiplier values which satisfy strong complementary slackness and analytic center solutions. Here we suggest a two-phase approach which can simplify matters as follows: Stage one, use the usual multiplier values, which are much easier to secure. Stage two proceeds in Thompson-Thrall manner to the more difficult strong complementary slackness and analytic center solutions. It is conjectured that stage one results will prove satisfactory in many applications. This can then avoid the need for stage two with its additional computational routines (including interior point methods) which are not present in currently available DEA computer codes.

EVALUATION OF ROBUSTNESS OF DECISION MAKING UNIT USING DUAL MULTIPLIERS

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Sensitivity analysis is a topic of great importance in DEA, either because data can be erroneous, or we can use procedures of sensitivity analysis to assess robustness of chosen DMU, i.e. how much data can change before an efficient DMU become inefficient. In the present paper we are interested in proportional changes of inputs and outputs of all DMUs, such that we increase inputs and decrease outputs of DMU under evaluation, and decrease inputs and increase outputs of remaining DMUs. In this approach we use dual multipliers obtained via extended, or superefficient DEA model. We also compare results with the approach of Thompson et al., where primal-dual interior-point method was used to obtain solution of dual program which is centrally positioned and satisfies strong complementary slackness condition.

Using superefficient DEA model, and obtaining dual multipliers from optimal simplex tableau for primal (envelopment) program we can assess percentage of possible changes which do not alter efficiency of DMU. Next, using parametric programming we can obtain set of dual multipliers with the property that DMU is efficient, after increasing its inputs and decreasing its outputs, if and only if at least one of the obtained dual multipliers is optimal for DMU. Numerical examples illustrating the results are provided.

SENSITIVITY ANALYSIS OF RETURNS TO SCALE CLASSIFICATIONS IN DEA

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Sensitivity of the returns to scale (RTS) classifications in data envelopment analysis is studied by means of linear programming problems. The stability region for an observation preserving its current RTS classification (constant, increasing or decreasing returns to scale) can be easily investigated by the optimal values to a set of particular DEA-type formulations. Necessary and sufficient conditions are determined for preserving the RTS classifications when input or output data perturbations are non-proportional. Our approach provides information on both the RTS classifications and the stability of the classifications.

Session 4 - Saturday 30/10/99 - 11.15 – 13.00
4B. SFA applications to agriculture

CROP AND SOIL SPECIFIC MINERAL EFFICIENCY AND PRODUCTIVITY IN FINLAND

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Alfons Oude Lansink, Wageningen University, The Netherlands

Combination of nutrients as inputs in cereal production has been modeled as a function of crop, soil type, region and phosphorous values in soil. Additionally a trend of changes in yields due to nutrient and to other factors has been included. Technical and input factor efficiencies were calculated for both soil types and crops. Stochastic output oriented production frontiers and stochastic input distance frontiers was calculated.

The frontiers can be used to analyze how changes in relative prices affects the combination of inputs and thereby the input factor efficiencies. This information is useful for assessment of regulations and economic instruments for nutrient control in agricultural production.

Data from a long-term (18 yr.) field trial experiment from different fields in Finland was used to estimate the stochastic translog production frontiers. The results shows remarkable high differences in average technical and input factor efficiencies due to soil type and region. Estimates of the parameters of the production frontier and input distance function are obtained using the FRONTIER package (Coelli, 1999).

FARM TECHNICAL EFFICIENCY AND EXTENSION

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This paper has a primarily technical focus in comparing alternative specifications of extension impact. Specifically, we take a stochastic frontier approach to estimate time variant and time invariant technical efficiency levels for individual farms using a fixed effects panel model and a maximum likelihood approach (Battese and Coelli 1992 specification) and test whether the estimated technical efficiency levels are associated with measures of contact with the advisory service.

The work is part of a wider project which seeks to estimate the impact of state-funded agricultural research and extension on Irish agricultural output and productivity as a step towards calculating a rate of return to these activities. In this paper, we focus specifically on the impact of the extension service in providing advice to farmers, whether by on-farm visits or through farmer participation in training courses run by the advisory service.

The method is applied to a sample of Irish farms recorded in the Irish National Farm Survey. The National Farm Survey is an annual survey designed to determine the financial situation on Irish farms and to measure current levels, and variation in, farm performance. Also available for the study are the results of an additional survey taken in 1995 which gives details on the extent and type of contact with the farm advisory service and the level of education. The data set comprises a balanced data set of 307 farms over the period from 1984 to 1994.

The results from all the models tested show that having contact with the advisory service through either a visit from the farm advisor or participating in a training course is significant in explaining the level of technical efficiency. Other significant factors are age of the farm operator, having a farm successor and having a higher level of education. There is evidence that the technology available on dairy and tillage farms is different to that of cattle farms - as seen through the higher intercept term in the production frontier - and that sheep farms relative to cattle farms have a lower production frontier. These rankings of farm system are important when analysing the impact of the extension service in Ireland since the operation of the extension service is divided along farm system lines. These results hold for both the single stage and two stage models of technical efficiency. This is the first time that the Battese and Coelli (1992 & 1995) two stage technical efficiency and single stage technical inefficiency methodology has been applied to Irish farm level data.

ANALYSIS OF ENVIRONMENTAL EFFICIENCY VARIATION

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C. A. Knox Lovell, The University of New South Wales, Australia
Geert Thijssen, Wageningen Agricultural University, The Netherlands

In this paper we develop and implement a methodology for explaining variation in environmental efficiency across firms. We formulate a two-stage model. In the first stage we use stochastic frontier analysis to

estimate both technical and environmental efficiency. In the second stage we again use stochastic frontier analysis to regress estimated environmental efficiency scores against a variety of technology, physical environment and management variables. We estimate the impacts of each explanatory variable on environmental efficiency. We also derive adjusted estimates of environmental efficiency from the one-sided error component. We illustrate our methodology with an empirical application to a panel of Dutch dairy farms. We find that environmental efficiency can be improved by policies encouraging a higher milk yield or providing farmers with more insight into the nutrient balance of their farms.

Session 4 - Saturday 30/10/99 - 11.15 – 13.00
4C. Organization

DEA BASED R&D INFRASTRUCTURE GRANT PROPOSAL SCREENING METHODOLOGY: FILTERING INFERIOR PROPOSALS USING INVERSE DEA AND INVERSE CROSS EFFICIENCIES

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In this paper we present a novel methodology for screening Research & Development infrastructure grant proposals, based on the application of Data Envelopment Analysis (DEA).

The advantage of DEA is that it allows the simultaneous comparison of all proposals over multiple criteria without relying on expert opinion. This work will be able to extract new information inherent in the data itself. Information which conventional methodologies would be unable to identify. It will allow each of the proposals to, in effect, vote on who is the best and who is the worst, as well as self-assess why they are the best and the worst. This is accomplished by extending current DEA theory in the area of Cross-Efficiencies to the case of Variable Returns to Scale (VRS). Extensions in the relatively new area of Inverse DEA will also be made with the development of Inverse Cross-Efficiencies.

Inverse DEA is a relatively new concept. Its foundation rests on the need to find the "inefficient" frontier as opposed to the traditional DEA efficient frontier. In a normal DEA analysis, we are trying to find those DMUs which are the best at producing outputs with their given inputs. In an inverse DEA model, we are attempting to find those units which are performing the worst. This is an important distinction and very applicable to the problem this research addresses. Being able to pick the best projects is very important but it is equally useful (and arguably more important) to be able to filter out the worst proposals.

The methodology involves the combined analysis results of four metrics: 1) Normal DEA score; 2) Normal Cross Efficiency Score; 3) Inverse DEA Score; and 4) Inverse Cross Efficiency Score. The results of the analysis (proposals accepted and rejected) will be validated against the actual accepted and rejected proposals made by committee members.

EXECUTIVE COMPENSATION, BOARD INFLUENCE, AND FIRM EFFICIENCY: DUTCH EXPERIENCE

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We investigate the executive pay-performance sensitivity on firm efficiency using Dutch corporate data. Although there is an extensive literature on executive compensation and firm performance using U.S. data, there is only a handful number of studies that focus on the European experience. Eriksson and Lausten (1996) evaluated 210 Danish firms finding weak evidence for pay-performance where as Brunello, Graziano and Parigi (1997) found stronger such relationship among Italian Corporations. Vagneur and Peiperl (1996) discussed the British experience providing mixed evidence. In addition to providing evidence on Dutch data, this paper makes contribution in the literature in a number of ways. First of all, the paper criticizes the criteria used to measure performance and provides arguments on using the measure of "productivity and efficiency" that incorporate firm's input, output, and the overall production and efficiency perspectives in evaluating firm performance. Second, the paper links the role of the compensation of primary and secondary board (outside) members' compensation in evaluating firm performance along with the usual executive payments and overall employee compensations. Unlike previous papers, this paper brings the most comprehensive analyses on the role of compensation in determining firm performance and vice versa.

DO BANK MERGERS HAVE HIDDEN OR FOREGONE VALUE? REALIZED AND UNREALIZED OPERATING SYNERGIES IN ONE BANK MERGER

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A widely publicized series of mergers has characterized the banking industry in recent years. Shareholder returns from these mergers have often been disappointing. This study finds delays in implementing potential operating savings and realizing benefits of scale economies may be one reason bank mergers have disappointing returns.

We analyze a 200 branch network formed in a merger of four banks. Data envelopment analysis (DEA) was used to benchmark the operating efficiency of each branch against "best-practice" branches within both the combined merged bank and the four individual pre-merger banks. DEA applied to the entire merged bank identified opportunities to reduce branch operating costs by 22 percent. In contrast, DEA benchmarking within each pre-merger bank suggests cost saving opportunity of under seven percent. This suggests that beyond traditional merger cost savings, such as closing branches, new added savings can be generated by benchmarking across the larger merged bank. More rapid and aggressive consolidations of management control systems in bank mergers may increase profits and shareholder value, improving returns in bank mergers. This study's contributions include: 1) exploring the potential new use of DEA in analyzing mergers; 2) confirming the value generated in bank mergers using internal operating data found in contrast to most studies using aggregated publicly reported data; 3) documenting one reason bank mergers may appear to have disappointing returns - deferred rationalization of merged banks' operations.

ON THE CAUSALITY BETWEEN GDP AND HEALTH CARE EXPENDITURE IN AUGMENTED SOLOW GROWTH MODELS

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This paper examines conditional convergence of OECD countries in gross domestic product (GDP) and health care expenditure (HE) per capita. It presents estimation of the augmented Solow growth model suggested by Mankiw, Romer and Weil (1992, QJE 107, 407-437) to explain variation in output and expenditure per capita across countries. The variation is due to different steady state growth paths resulting from differences in the countries savings rate, education, and population growth. This paper is an extension of the MRW paper to health care expenditure augmented Solow model. The analysis is further related to the studies of health care expenditure where GDP per capita appear to be the main factor determining the level of expenditure on health care. The issues of causality relationship between GDP and HE is investigated. The empirical analysis is based OECD countries' data for the period of 1970-1992. Results indicates that OECD countries converge at the rate of 2.7 % per year to their steady state of income per capita with the usual Solow model. The results show, that HE has significant effect on the economic growth and the speed of convergence. When investments in health is explicitly taken into account in the model, the speed of convergence is increased to 3.7 %. The speed of convergence is also found to be sensitive to whether one imposes a constant or estimate the depreciation and technological growth components. Considering the rate of convergence in the HE model the results show that OECD countries converge at 2.5 % to their steady state of HE per capita. In the later models a regression of the speed of convergence on variables determining the rate of convergence show close link to the variables characterizing the health care system of sample countries.

TESTING DEA MODELS OF EFFICIENCY IN NORWEGIAN PSYCHIATRIC OUTPATIENTS CLINICS

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While measures of output in mental health care are even harder to find than in other health care activities, some indicators are available. In modelling productive efficiency the problem is to select the output variables that best reflect the use of resources, in the sense that these variables have a significant impact on measures of efficiency. The paper analyses cross-sectional data on the psychiatric outpatient clinics of Norway using the Data Envelopment Analysis (DEA) non-parametric efficiency measurement method, and tests the variable specification using statistical tools recently introduced in the literature. In addition to outputs, the importance of different profession or educational groups on efficiency is examined, and results are compared for separate samples of clinics for children and youths (BUP) with clinics for adults (VP).

OWNERSHIP, CASE MIX HETEROGENITY AND HOSPITAL OWNERSHIP

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This paper investigates the potential impact of ownership and case mix heterogeneity on the productive efficiency of hospitals. Does the type of ownership impact the goals of hospital management and, in turn, how efficiently hospitals operate? Economic theory suggests that managers of for-profit organizations may have greater incentive to operate more efficiently than managers of not-for-profit organizations. Previous studies on hospital efficiency, such as Grosskopf and Valdmanis (Journal of Health Economics, 1987), Valdmanis (Journal of Public Economics, 1992), and Ferrier and Valdmanis (Journal of Productivity Analysis, 1996), to name a few, compared for-profit with not-for-profit hospitals, or government with other not-for-profit hospitals. Our analysis differs from previous papers by separating not-for-profit non-government hospitals into church operated versus other hospitals (primarily church affiliated and community hospitals). This further separation allows us to examine whether there are differences in productive efficiency among different types of not-for-profit hospitals.

Furthermore, with regard to case mix heterogeneity, most studies on hospital efficiency, including those studies mentioned and Eakin and Kneisner (Southern Economic Journal, 1988), use several variables to measure hospital output (outpatient visits, discharges, and inpatient days to name a few). Hospitals differ in the mixture (distribution) of cases that they treat: small rural hospitals typically treat less complex (and less costly) cases compared to large urban hospitals. Case mix heterogeneity is prevalent in the measurement of hospital outputs. Efficiency measures that do not take case mix heterogeneity into account give all cases the same weight. As a result, the efficiency measures of some hospitals may be understated or overstated relative to more accurate estimates that incorporate case mix heterogeneity. Finally, this paper also differs from previous studies by using a case mix index to account for case mix heterogeneity in the productive efficiency scores.

The data set is derived from the 1996 American Hospital Association's (AHA) Guide to the Health Care Field, and the Profiles of U.S. Hospitals. The data sample consists of 453 general medical and surgical hospitals operating in the Midwestern U.S. The composition of hospitals by state are 157 from Illinois, 82 from Indiana, 113 from Ohio, and 101 from Wisconsin. Among the non-governmental, not-for-profit hospitals there are 108 church operated hospitals and 250 non-church operated hospitals. Variables in the data sample include three output measures, two input measures, a case mix index and type of hospital ownership. While the studies mentioned above used data from the AHA, we are not aware of studies that have utilized data from the midwestern states. Both DEA and parametric estimation techniques are used to compute measures of productive efficiency.

Session 5 - Saturday 30/10/99 - 14.00 – 15.45
5B. New efficiency measures

A NEW EFFICIENCY MEASURE CONSISTENT FOR AGGREGATION

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Recent developments in the non-parametric frontier literature explore relationship between firm, group of firms and industry models. Färe, Grosskopf and Li (1992) compare industry and firm models in the single output case, Li and Ng (1995) consider several outputs but use the industry model shadow prices as aggregation weights. Dervaux, Kerstens and Leleu (1999) work with efficiency indices based on input slacks. In order to generalize previous approaches, we address the question of the aggregation properties of usual efficiency indices (as defined by Debreu-Farrell, Färe-Lovell or Zieschang). Unfortunately, as Blackorby and Russel (1994) have showed, these indices cannot be consistently aggregated. In this paper, we introduce a new efficiency index which satisfies the conditions for aggregation consistency while keeping meaningful economic interpretation. Formal relationship between industrial and firm efficiency models are proved and links with other efficiency indices are analyzed. This new index can be used either for aggregation of efficiency indices across firms either for inputs/outputs aggregation [Klein (1946), Nataf (1948)]. In the former perspective, it may be proved useful to measure inputs/outputs reallocation between firms and to test merging effects [Bogetoft and Wang (1996)]. In the latter perspective, it may be helpful to determine the number of outputs and/or inputs in the production function.

A DIFFERENTIAL DECOMPOSITION OF PROFIT EFFICIENCY: AN APPLICATION TO U.S. BANKS

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Farrell (1957) introduces the concept of cost efficiency measured by the ratio of the minimum cost of producing the observed level of output of a firm and its actual cost. He further decomposes this cost efficiency as the product of its technical and allocative efficiencies. The technical efficiency of the firm reflects the maximum equi-proportionate reduction in its inputs without reducing output. Elimination of technical inefficiency scales down the actual input bundle of the firm to a point on the efficient isoquant for its observed output level. Allocative efficiency is the ratio of the minimum cost of producing the given output level to the cost of this technically efficient bundle. All three efficiency measures lie between zero and one.

Banker and Maindiratta (1988) measure the profit efficiency of a competitive firm similarly by the ratio of its actual profit and the optimal profit given the input and output prices. Further, they derive the technical efficiency of the firm by the ratio of its actual profit and its technically efficient profit. Several potential problems emerge with this decomposition of profit efficiency, however. First, unlike in the case of cost-minimization, the factor that represents technical efficiency depends on prices. Second and more important, if the actual profit of a firm is negative, then measured profit efficiency is negative, when the maximum profit is positive. When the maximum profit is also negative, then the ratio is again positive but greater than one. Banker and Maindiratta (1988, 1324-5) briefly note this latter problem and suggest an alternative decomposition based on profit differences. We adopt this suggestion.

In this paper, instead of measuring efficiency by the ratio of actual and optimal profit, we focus on the lost profit due to inefficiency measured by the difference between the firm's optimal and actual profit. This difference is always positive even if actual profit, by itself or in conjunction with optimal profit, is negative. We then provide a differential decomposition that shows what proportion of this loss is due to technical efficiency and what proportion is due to allocative inefficiency. Moreover, we derive decompositions using input- and output-oriented projections to determine technical efficiency.

We employ an empirical application using the observed input and output price and quantities of 614 large banks in the U.S. from the year 1996 to illustrate our proposed decomposition to quantify the relative importance of technical and allocative inefficiencies in accounting for unrealized profits. Such empirical results may provide valuable information for managerial control and/or government regulation.

Several systematic empirical findings emerge. Technical efficiency improves as bank size increases and that the part of lost profit attributable to allocative problems also rises as bank size increases. The seven largest banks with assets above $50 billion achieve a high degree of technical efficiency and lost profit due to profit inefficiency is largely a result of allocative inefficiency.

DETERMINING THE BEST DEA EFFICIENCY EVALUATION OF A SET OF UNITS

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Fernando Borrás, Universidad Miguel Hernández de Elche, Spain

We will show how to determine the shortest L1-path to the frontier. This is the key for achieving the best efficiency evaluation of a given set of units within the DEA framework. We further will show that this method evaluates the units "better" than the actual methods, such as the DEA radial or additive models, or even the step by step radial contraction method recently proposed by Coelli.

Session 5 - Saturday 30/10/99 - 14.00 – 15.45
5C. Value and goal models

RESTRICTING WEIGHTS IN VALUE EFFICIENCY ANALYSIS

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In this paper, we consider the problem of incorporating additional preference information into Value Efficiency Analysis by using the "price" information of inputs and outputs. This is done to improve the accuracy of the estimation of the Value Efficiency Scores. Value Efficiency developed by Halme et al. [1998] is an efficiency concept, which takes into account the decision maker's preferences. Value Efficiency Analysis is based on the assumption that an implicitly known value function reaches its maximum at the Most Preferred Solution on the efficient frontier. The Most Preferred solution is an input-output vector preferred to all other possible input-output vectors. The ultimate goal is to measure a need to improve (radially) the values of inputs and/or outputs to make them equally preferred to the Most Preferred Solution. Because we do not know the value function, we approximate the indifference curves of all possible value functions satisfying certain assumptions by their tangents at the Most Preferred Solution. The resulting cone of the tangents consists of points less or equally preferred to the Most Preferred Solution. However, in addition to the Most Preferred Solution information about the "prices" of inputs and outputs may be available as well. We show how this information can be incorporated into the analysis and illustrate the approach by an example on the performance of municipal dental units in Finland.

MEASURING AND EVALUATING EFFICIENCY AND EFFECTIVENESS USING GOAL PROGRAMMING AND DATA ENVELOPMENT ANALYSIS IN A FUZZY ENVIRONMENT

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Crisp mathematical programming techniques have shortcomings when used for measuring and evaluating achievement of organizational goals in a decision-making environment. Generally, in most situations optimal achievement of multiple goals is rarely possible. In such cases, a compromise achievement of goals that leads to a *satisfycing* solution rather than an *optimal* solution bears more relevance.

The present research introduces a framework to measure and evaluate the goals of efficiency and effectiveness in a fuzzy environment and is developed using Goal Programming, Data Envelopment Analysis and Fuzzy Set Theory. The proposed framework called Fuzzy Goal Data Envelopment Analysis (Fuzzy GoDEA) uses surrogate constraints for efficiency and effectiveness. Data Envelopment Analysis (DEA) type constraints are used to model the efficiency goal. The effectiveness goal is represented by the aggregate efficient contribution of the individual decision-making units toward achievement of the global organizational targets. Concepts of fuzzy set theory and goal programming are used to model the imprecision in goal achievement and the relative importance among goals. Additionally, the concept of minimal operational viability is introduced. This concept refers to the least proportion of the available global inputs and outputs that must be allocated to pre-specified Decision Making Units (DMUs) to assure a minimal level of production.

The Fuzzy GoDEA framework accommodates crisp input and output data but allows imprecise specification of the aspiration levels for the efficiency and effectiveness goals. The imprecision in goal achievement is allowed through the specification of an interval of acceptable achievement rather than a crisp value. A membership function is defined for each fuzzy constraint associated with the efficiency and effectiveness goals and represents the degree of achievement of that constraint. Further, the Fuzzy GoDEA framework is extended into several variations that (i) allow the assignment of relative importance to the goals of efficiency and effectiveness and (ii) model scenarios where one of the goals of efficiency and effectiveness is crisp and the other fuzzy.

The Fuzzy GoDEA framework is implemented for newspaper preprint insertions process (NPIP). Detailed analyses of the results are presented to describe the information available from the Fuzzy GoDEA methodology that can be used in conjunction with conventional DEA analysis to assess and improve the efficiency and effectiveness performance of the NPIP process.

A GOAL PERSPECTIVE OF DEA

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Transformation of inputs or outputs is one of the most frequently used ways of dealing with undesirable inputs or outputs in order to apply the classic DEA models to such applications. The current understanding is that this method may change the efficiency scores, but should not affect the efficiency classification if the transformation is "meaningful". In this work, we first show that a seemingly common sense transformation of the outputs in an application can lead to the efficiency classification which is completely different from

the well-established conclusion in a antidepressant pharmacotherapy evaluation. Then we derive some new DEA models which are designed to cope with the applications with undesirable inputs or outputs, via multiple criteria decision making theory. These models are applied to the evaluation.

Session 6 - Saturday 30/10/99 - 15.45 – 16.45
6B. Poster session

Hospital/medical

PRODUCTIVITY OF MEDICAL STAFF

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The productivity (workload) in hospital departments of different specialties during the three-year period is evaluated. For the analysis, the data envelopment analysis is used. The inputs are the number of physicians and the number of paramedical personnel. The outputs are the number patient days (intensive care), the number of patient days (non-intensive care) and the number of patients. No a priori relations are assumed to hold for the weight values for which the model is solved in the original CCR model. However, if the complete flexibility in choice of weights is permitted, the model will often assign unreasonably low or high weights to some factors. The hospital management will hardly accept productivity ratings with extreme factor weights. We assume, for example, that the weight of physician work, albeit exactly unknown, should be certainly higher than the one of paramedical personnel, or the weight of the patient day on intensive care unit should be higher than on other units. The relative efficiency score calculated by DEA is used as a tool to determine the case-mix adjusted productivity. Since the departments are of different specialities, a problem of case-mix must be solved. We assume that the best score for a given department for all periods represents the efficient unit. If such score is greater than one, the score shows the influence of more complicated case-mix on the workload in a given department. Therefore, one cannot claim that the productivity of staff is low. According to our view the output should be multiplied by the score in order to gain the case-mix adjusted productivity (workload). If the score for the same department but different period is higher then the lower productivity is identified. However, one must be very careful in his conclusions. For instance, a change in the technology is possible explanation. The problem to be solved is whether a decision-making unit can choose the different weights in the different periods. The values and priorities can and surely are changing, but one may expect some continuity.

EXPLAINING THE EFFICIENCY PATTERN OF HOSPITALS DIAGNOSTIC TECHNOLOGIES: A MULTILEVEL ANALYSIS

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Over the last decade, policy debate on the health sector has increasingly centred around questions of performance in the main Western countries. In particular, hospital diagnostic technologies have been closely scrutinized given their important contribution to the growing health care expenditure (Crowe, B.L. and Hailey, D.M., 1989).

The purpose of this paper is to obtain empirical measures of performance in the management of the main diagnostic tools for 9 DRGs over the period 1992-94 in the main Portuguese hospitals and to identify the environmental factors affecting the efficiency pattern. The work is articulated into two phases: in the first one, technical efficiency scores for diagnostic tools are derived using Data Envelopment Analysis (DEA). However, unlike previous works in this field, the decision-making unit is not the hospital, but is the single

service taking resource allocation decisions in an individual production process, i.e. a patient. In addition, measures of quality and severity of illness are introduced in the output/input set to control for the impact of these factors on the outcome of the productive process.

In the second phase, the relationship between the obtained efficiency patterns and environmental factors (e. g. hospital characteristics) is analysed. As the technical efficiency scores are measured at the service level and the hospital characteristics are observed for the whole hospital, the empirical analysis is conducted using multivel regression models devised to correctly identify empirical relationships between variables at different levels of aggregation (Goldstein, H., 1995).

Bootstrap

A BOOTSTRAP ANALYSIS OF TECHNICAL, EFFICIENCY AND PRODUCTIVITY CHANGES IN SPANISH AIRPORTS USING THE MALMQUIST INDEX

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In this paper we analyze both efficiency and productivity changes in Spanish airports in the period 1992-94. We use Malmquist indices since among other advantages this index allows to decompose the total productivity changes into two different sources of variation, efficiency and technical changes. The production functions can be estimated through DEA but one of the main drawbacks about the use of these techniques is that they do not allow for measures errors and other random effects in the sample, therefore the lack of confidence intervals around the estimated efficiency is a crucial difficulty. Bootstrap techniques appear to be a very well suited device to overcome the previous difficulties (Simar and Wilson, 1998). We assume technologies with constant, variable and decreasing returns and we calculate a scale index estimator using the efficiency measures. We consider a variable returns to scale technology and we use the bootstrap methods to obtain bias corrected estimates of both decompositions of the Malmquist index. Although the time period analyzed is fairly short, we study the impact of the crisis in the productivity and in the efficiency of the Spanish airports.

BOOTSTRAPPING DEA-AR EFFICIENCY SCORES

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This paper presents the Bootstrap estimation technique applied on DEA models which includes bounds on the dual multiplers. It is analyzed how Assurance Regions influences the calculated bootstrap parameters. It is shown on a large dataset that changing the Assurance Region parameters influences the calculated bootstrap parameters in a counter intuitive direction. The dataset is based on 70 Danish hospitals each represented by one input and 483 outputs. The large amount of outputs is a result of catagorizing observed discharges by the Diagnose Related Group (DRG)-based casemix-system.

Transportation

PARAMETRIC DEA ANALYSES OF AIRLINE MARKETING INVESTMENTS

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SAS has a sales organization encompassing districts in Denmark, Norway, Sweden, and the International areas. We have recently applied mathematical techniques to make sure that marketing investments are focused in the best way possible. In two such projects we applied Data Envelopment Analysis; one aimed at assessing the effects of training the sales staff. The other was conducted in cooperation with the city of Stockholm with the purpose of verifying increased incoming traffic as a result of marketing campaigns abroad. Factors that might have explanatory power were identified; parametric models of sales volumes were outlined using business logic; Data Envelopment Analyses was applied, and DEA efficiency analyzed. Some numerical results are presented.

THE ALLOCATIVE INEFFICIENCY AND ITS COST IN SPANISH RAILWAYS

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This paper is an empirical application of the distance function to study the allocative inefficiency and its cost of a regulated railway firm, RENFE, where the cost minimising hypothesis may be questioned. The distance function, which is the dual of the cost function, completely describes the technology and, like the cost function, it allows a multiproduct analysis. However, unlike the cost function, the input prices are not needed for its calculation and it does not imply cost minimisation.

By means of this technique we have obtained the shadow prices of the productive factors, which satisfy the condition of minimum cost. These shadow prices are used to calculate the degree of allocative inefficiency of the firm and the origin of this inefficiency by using a parametric correction of prices. The procedure followed has consisted of estimating a system of equations for the input distance function and cost share equations, employing the iterative seemingly unrelated regressions method. The model was estimated using annual data over the period 1955-95. In order to achieve a distribution and the confidence intervals of the proportionality terms estimated, we have used a standard bootstrap technique.

The results of this study indicate that there is no allocative efficiency, since the calculated shadow prices are different to those of the market. To be precise, we have observed an overutilisation of labour relative to capital and energy.

This overutilisation could be due in a some way to the difficulty of adjusting the optimal labour quantity in a regulated environment such as that in which RENFE operates. However, beginning in 1984, the greater possibilities for substitution between factors -as indicated by the Morishima elasticities of substitution- have raised the costs associated with inefficient behaviour. This, along with the coming into force of the programme contracts, seems to have motivated the executives to choose input combinations which improve allocative efficiency. As an example, since 1984 the proportionality term between labour and capital has adjusted to reach values close to the efficient level.

Theory

A SHADOW PRICE APPROACH TO TECHNICAL EFFICIENCY MEASUREMENT

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The axiomatic literature on technical efficiency measurement has drawn attention to the indication problem of the Debreu-Farrell (DF) measure. We follow a shadow price approach to preserve the DF benchmark while reconciling it with the Koopmans efficiency characterization. First, we define a set of Koopmans efficient references that can be rationalized in a similar way as the DF projection. The indication problem is then captured using a measure of implicit allocative or mix efficiency, also interpretable as a dominance measure in price space. We consequently present a mix-adjusted DF framework for efficiency measurement in which e.g. the Zieschang (1984) procedure can be fitted.

SOME MODELS FOR MEASURING (SUPER-)EFFICIENCY OUTWITH THE VRS CONVEX HULL

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Some approaches to productivity measurement depend on measuring the 'distance' from a DMU to a convex hull spanned by other DMU'S: calculating Malmquist productivity indices is one example, 'superefficiency' measurement is another. The usual DEA models exhibit deficiencies when applied to this task for the desirable case of Variable-Returns-to-Scales. Two models are presented for this purpose, which are generalisations of radial and additive models respectively. Further, these models exhibit other properties which make them universally useful: units and translation invariance. The theoretical background of the models and their properties is discussed, and results from a European industrial implementation are shown.

DATA ENVELOPMENT ANYLYSIS OF NON-CONVEX TECHNOLOGY: WITH AN APPLICATION TO FINNISH SUPER LEAGUE PESIS PLAYERS

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We argue that Data Envelopment Analysis (DEA) methodology has produced an axiomatic acceptance of convexity hypothesis that seriously contradicts the rationale of DEA. We show empirical evidence from production technology employed by Finnish Super-League pesis players, which demonstrates that the typical convexity axioms can be seriously violated. As these theoretical and empirical findings put the axiomatic DEA into serious question, we propose a general Non-convex DEA approach to offer an alternative approximation of the true but unknown production technology. Non-convex DEA technology is defined as the largest set constructable as a union of convex free-disposal hulls formed from subsets of the efficient DMUs, provided that no efficient DMU is dominated by any other point of this set. Interestingly, this generalization contains the usual free-disposal hull and convex free-disposal hull approximations as its limiting special cases. We illustrate the Non-convex DEA approximation with the application to Finnish pesis batters.

Banks

CREDIT RISK AND EFFICIENCY IN THE EUROPEAN BANKING SYSTEMS: A THREE-STAGE ANALYSIS

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Increased competition and the attempts of European banks to increase their presence in other markets may have affected credit risk due to their lack of knowledge of such markets and/or acceptance of a higher risk in order to increase their market share. Despite the importance of these aspects, banking literature has usually analysed the effects of competition on the efficiency of banking systems without considering these aspects. The few studies that attempt to obtain risk adjusted efficiency measures do not consider that part of the risk is due to exogenous circumstances. This article proposes a new three stage sequential technique, based on the DEA model and on the decomposition of risk into its internal and external components, for obtaining efficiency measures adjusted for risk and environment. It is seen that the technique allows the use of any existing technique of incorporation of environmental variables in DEA analysis.

THE RELATIONSHIP BETWEEN COST AND PROFIT EFFICIENCY IN THE FRENCH BANKING INDUSTRY SINCE 1993

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This paper analyses the relationship between the cost and profit efficiency in the French banking sector over the period 1993-1997 by using distribution free efficiency measurements. The detailed and exhaustive data come from the confidential accounting data base which exist in France for the purpose of prudential regulation. For different functional forms, we show first that efficiency scores do not depend on size or on bank types (commercial banks, co-operative and mutual banks, savings banks) and second that there exists a negative link between cost and profit efficiency for the entire sample or at least for subsamples. It appears in particular that high cost efficiency banks are likely to be low profit efficiency banks and, on the reverse, that low cost efficiency banks are likely to be high profit efficiency banks. However, the negative correlation between cost and profit efficiency does not necessarily hold for the entire period - it is more pronounced for the period after 1994 - nor for all types of banks.

The paper explores three different explanations of these features. The negative link may result form increased investments (in order to offer more and/or better services) which translate into lower cost efficiency, but higher profit efficiency. This argument explains simultaneously the fact that a bank is characterized by a low cost and a high profit efficiency, and - since efficiency scores are relative indicators - the reverse phenomenon (high cost and low profit efficiency) which may be due to the absence of a quantitative and qualitative improvement in the offer of services. Moreover, two other explanations of the two opposite combinations of cost and efficiency exists. The first one establishes a link between low cost efficiency and X-inefficiency. Here for some reason (e.g. existence of market power) a bank does not have enough incentives to reduce managerial slack as much as others do. The second interpretation assimilates low profit efficiency with imperfect competition. This means that banks which have undergone many efforts in reducing managerial inefficiencies may choose to offer, for strategic reasons, their services at prices which do not allow them to generate important profits.

The analysis suggest, at least for a subsample of banks, that performance improvements in the French banking industry depend as much on a modification of the competitive framework which would raise profit efficiency than on restructuring and internal reorganization which would enhance cost efficiency.

A FRAMEWORK FOR ASSESSING MEDICAL TREATMENT AT THE PROCEDURAL LEVEL

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The essential mission of a hospital is to admit patients and make them well. This fundamental purpose may at times be lost in the quagmire of insurance rules, medicare and medicaid reimbursements, DRG classifications, federal and state regulations, merger propositions, research demands, medical student training, care for the indigent, wage pressures, and much more. For these reasons, it is more important than ever to measure, to monitor and to improve the effectiveness of patient care.

This paper presents a framework for assessing the medical practice at the procedural level. Numerous studies evaluate the overall performance of hospitals. Very few studies evaluate how well a hospital performs a procedure. A procedure-based evaluation of hospitals may enrich and supplement an overall evaluation in useful ways. It identifies areas in which a hospital performs well, and areas in which it performs poorly, rather than some measure of average hospital performance. Because performance measures at the procedural level provide feedback on specific areas of weakness, they can be used to develop programs for performance improvement.

The framework is outlined for two medical procedures: (1) mechanical ventilation and (2) coronary artery bypass surgery. The inputs and the outputs are constructed from patient data. The SPARCS data contains detailed information on all individual patients in New York State hospitals. This includes measures of their pre-condition and measures of outcomes. The objective of a medical procedure is to transform sick persons into healthier persons.

For mechanical ventilation, the analysis is at the hospital level. The precondition and outcome measures that serve as inputs and outputs are aggregated to the hospital level by taking averages for all of the patients treated in a given procedure at a particular hospital. For coronary artery bypass surgery, the analysis is at the physician level. Measures of pre-condition and measures of outcome are aggregated to the physician level by averaging over patients. Data envelopment analysis (DEA) is used to determine units (hospitals in the first case and physicians in the second case) that are more successful and those that are less successful in treating patients with a set of pre-conditions.

MODELING ECONOMIC BEHAVIOR IN DEA-SETTING: THE CASE OF DUTCH GENERAL HOSPITALS

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Introduction

In the literature on efficiency of firms economic behavior plays an important role. Models for the efficiency are often based on assumptions on the economic behavior of the firms. Well-known assumptions are cost minimization, revenue maximization and production maximization. Moreover assumptions are made about

the restrictions the firms are faced with. For instance the quantity of production that has to be attained may be given, or the revenues to be assessed. In microeconomic, literature there is a well-known theory on modeling these assumptions and restrictions. The theoretical relationships between the various models are described extensively, see for instance Färe and Primont (1995). Most literature on these behavioral assumptions is based on parametric models for the production structure. Following Färe et al. (1994) it is also possible to model the different types of economic behavior in a nonparametric setting. The purpose of this paper is to use four non-parametric models in order to determine the economic behavior of firms empirically, rather than make assumptions beforehand. The models correspond to the cost and revenue functions and the indirect cost and revenue functions derived from the parametric literature. In particular the method of Data Envelopment Analysis is employed here. The models are applied to a dataset of Dutch general hospitals in the period 1985-1995.

Dutch hospital industry

The Dutch hospital industry has some special characteristics. General hospitals are fully reimbursed by insurance companies on a prospective basis. Budgets are based on local agreements on the numbers of first-time visits, in-patient days, day-care patient days and the number of admissions. To some extent the budgets are based on the severity of cases. Larger hospitals, who are assumed-to treat more severe cases, receive higher budget rates. Although any surplus does remain available to the hospital, it is not allowed to make any profits. Surpluses are added to the capital assets. in the long run, revenues and costs have to stay in equilibrium. Since wages are regulated as well, the possibilities of the management to increase their own salaries are very limited. Hence, in his case not-for-profit can not be a matter of 'for-profit in disguise'. In spite of these regulations, general hospitals are in competition. General hospitals with deficits and negative capital assets will be subjected to budget cutbacks and finally closed down. Therefore, growth and expansion of high tech medical treatments are important goals. From these characteristics it is not clear whether Dutch general hospitals are cost minimizing or revenue maximizing firms. It is also questionable under which economic constraints they operate: output, revenue, input or cost constraints.

Economic models

We formulate four models for different assumptions on economic behavior, which are well-known in the parametric literature. We model the DEA correspondences of the direct and indirect cost function model and the direct and indirect revenue function model. Each model is analyzed separately by using Data Envelopment Analysis and the results are compared. Several criteria are given on which an empirical choice for the appropriate model can be based.

Data

Data for this study were obtained from the Ministry of Public Health covering the years 1985-1995. The data were collected by the National Institute of Public Health and are derived from several surveys, such as financial, patient and personnel surveys. These files contain information on more than 100 hospitals each. year. From the extensive. data set we choose 2 quantitative main outputs: the number of discharges and medical research. The number of discharges is differentiated on medical specialism. Physicians time not related to patient care is used as a proxy for medical research. Output prices for the different types of discharges are derived from the budget parameters according to the budget system. They vary over firms and years. Medical research is assumed to be a fixed output in all models. Inputs include nursing personnel, para-medical personnel, other personnel, materials and capital. Capital is assumed to be a fixed input in all models. Input prices are measured as a hedonic price index based on region and time period.

Empirical results

The efficiency scores for the hospitals are calculated for each of the four economic models. The results show that the mean total inefficiencies vary from 0.16 and 0.28 between the four models. The sets scores for individual hospitals differ significantly between the models. The same holds for rankings of the hospitals according to their efficiency scores. This indicates the importance of modeling the appropriate economic assumptions. Also the results also show that the direct models are to be preferred to the indirect models. This conclusion can be drawn by calculating the inefficiency of output-allocation in the cost minimization models and the inefficiency of input-allocation in de the revenue maximization. models. Moreover, from the scores it can be seen that the cost minimization. model seems to fit the data better than the revenue function model. The conclusion of this paper is that based on the (mean) efficiency scores some models are preferred over others. A comprehensive test procedure should be developed in order to give a definite answer on which model should be chosen.

DO HOSPITAL MERGERS RESULT IN IMPROVED SCALE EFFICIENCY?

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Over the past decade, U.S. hospital markets have become more price competitive. One reason for the increase in price competition is the proliferation of managed care which reimburses hospitals with a fixed, predetermined price rather than the more generous fee-for-service. In response to greater market pressure, hospitals must improve their efficiency or face financial ruin. Hospitals can cut costs by increasing (1) technical efficiency -- reduce the number of inputs to produce outputs; (2) allocative efficiency -- use the right mix of inputs to produce outputs; and (3) scale efficiency -- become the "right" size of the hospital. Using the Data Envelopment Analysis (DEA) approach, the components of efficiency are determined using linear programming methods. The benefits of DEA include its ability to deal with multiple inputs and outputs as well as allowing flexibility in determining the best practice frontier. This frontier is produced by the efficient hospitals as compared to all hospitals (efficient and inefficient) in the sample. The degree of inefficiency is equivalent to the distance of an inefficient hospital to the frontier. By relaxing certain constraints, we can decompose total efficiency into separate measures of technical, allocative, and scale efficiencies. Of particular interest for this paper is determining if hospital decision makers may improve scale efficiency by merging two hospitals together in order to form a single entity.

Hospital mergers have been on the rise in the U.S. One of the most cited reasons for merging hospitals is so that scale efficiencies can be exploited. This argument focuses primarily on the newly merged entity's ability to get inputs at lower prices because of bulk purchasing. Whereas this type of cost cutting measure is potentially important in decreasing over-all hospital costs, it is mostly an accounting saving, rather than the efficicient use of real resources We use the DEA approach on a set of hospitals that merged in 1997 in order to determine if resource use was optimized due to increasing returns to scale. We use data from the 1996 and 1997 American Hospital Association Survey of Hospitals.

Our research consists of a two step process. In the first step, we analyze the merging hospitals in 1996 (before they merged) with a matched set of hospitals which remained un-merged in 1997. Matching will be based on (a) bed size, (b) non-federal ownership, and (c) teaching status since these factors are important organizational differences that affect market conditions. This step of the research is performed to determine if any systematic/organizational differences exist between hospitals which eventually merge from those which do not (holding the matching criteria constant). In our second step of the research, we assess the merged hospitals with a new set of matched pair hospitals via the DEA methodology to determine if economies of scale have been achieved through the merger. The new set of matched pair hospitals is constructed in the following way. Each hospital that eventually merged in 1997 had a matched pair hospital

in 1996. We take the corresponding matching hospitals that did not merge and add them together. The merged hospitals and the hypothetically merged hospitals are combined to form a new sample. The DEA results using the new 1997 sample will provide information if scale efficiency can be achieved through organizational restructuring (i.e., merger) or if a change in scale efficiency can stem from simply adding two hospitals together.

In the past there has been a problem in analyzing merging organizations using DEA , because it ultimately alters sample size. We propose this alternative approach in order to study effects of hospital mergers while possibly mitigating the sample size problem.

Session 7 - Saturday 30/10/99 - 16.45 – 18.30
7B. Comparisons in agriculture

INTERNATIONAL TRADE, COMPETITIVENESS, AND PRODUCTIVITY

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Economists have focused considerable attention on the issue of competitiveness in recent years with the objective of understanding the determinants of a nation's ability to compete in world markets. With this objective in mind several studies have focused on the calculation of costs of production by commodities and on the comparison of these magnitudes across major competitors (Ortman, Stulp and Rask; Seecharan; Stanton). It has been found that these comparisons have not been very helpful in understanding competitiveness nor in describing the forces affecting the supply and export supply of the commodities of interest (Sharples, Ahearn, et al.).

Competitiveness does not have a definition in neoclassical economic theory. In fact if firms cannot survive by selling at the going price and loose market share, it said that they are not competitive. In this case one's gain is the other's loss (a zero sum.) But countries are not firms, they do not disappear, and international trade is not a zero sum game. It is well known that countries that "compete" through trade do not loose.

The World Economic Forum considers that competitiveness refer to "the ability of a country to achieve sustained high rates of growth in GDP per capita." The Council of Economic Advisors of the President refers to it as "the ability of to produce goods and services that meet the international test while enjoying a standard of living rising and sustainable." There are other variants in the literature but most coincide on the notion that competitiveness refers to a country's future prosperity depending on its growth in productivity .

In the neoclassical general equilibrium models of international trade, countries trade with each other because of their differences. Countries may differ in their technologies or their factor endowments, and these differences jointly determine comparative advantage and, hence, trade. In contrast with competitiveness, comparative advantage is a well defined theoretical concept which explains trade and optimal welfare in an undistorted world. Technology differences as a source of comparative advantage were first studied by Ricardo, who identified different relative factor productivities as the cause of trade, while Heckscher and Ohlin assumed away technology differences and focused on differences in relative supplies of capital and labor as the causes of trade. Modern theorists recognize that general technology and factor supply differences can jointly determine comparative advantage. While this has been the standard model of trade for many years, economists have spent little effort on empirical evaluation of the model, and most tests have been inconclusive or unfavorable to the model, beginning with Leontief's (1954) famous paper showing that the factor content of U.S. trade is not consistent with the model's predictions. Starting with Leamer (1984), several researchers have used theory in a careful way to evaluate versions of the factor proportions explanation of specialization and trade, including Maskus (1985), Bowen et al. (1987), Staiger (1988), and

Harrigan (1995). Each of these efforts has explicitly assumed identical technologies across countries, but the theoretical results are not very satisfactory, implying, for example, that the capital/labor ratio in Japanese agriculture should be the same as the capital/labor ratio in Brazilian agriculture. These models conflict with direct evidence by Jorgenson and Kuroda (1990), Dollar and Wolff (1993), Van Ark and Pilat (1993) and Harrigan (1996, 1997) that technologies differ.

As noted above, general versions of the factor proportions theory have been subject to a fair amount of empirical scrutiny. In contrast, the author is not aware of such efforts to evaluate general technology differences as sources of comparative advantage. This impression is supported by the surveys by Deardorff (1984) and Leamer and Levinsohn (1995); neither find any studies that evaluate the Ricardian explanations for trade, never mind studies that look at the joint impact of technology and factor supply differences. In addition, changes in technology are a source of productivity change with technological biases underlying changes in comparative advantage and therefore competitiveness.

One aim of this paper is to fill this gap in the literature. This work will propose an empirical model which is flexible enough to jointly estimate the impact of differing and evolving technologies and changes in factor supplies on international specialization and trade. The model comes from applying a flexible functional form to the distance function representation of the general equilibrium of the production sector where there are Hicks biased technology differences across commodities and over time. The model requires a minimal number of assumptions beyond the most basic ones (exogenous prices and factor supplies.) This model is estimated with data over the 1950-1995 period for the U.S. agricultural sector with five outputs and three inputs. Technological change and output and input biases are measured form the distance function.

This paper takes the view that the determination of economy-wide inverse supplies and derived demands of agricultural commodities is a general equilibrium phenomenon, where developments in one market for goods or factors influence equilibrium in other markets. The model presents a representation of a competitive economy's equilibrium to specify a system of equations that explains inverse supplies and derived demands as a function of relative factor endowments, relative quantities of outputs supplied, and technological progress. In this context the predictions of the Heckscher-Ohlin-Samuelson model and the Rybzinsky model are examined. The theoretical fragility of these models is made evident as the production structure chosen is general enough to allow for many goods and factors, joint production, and variable returns to scale.

A number of other relationships estimated are of interest, among them the development of an equivalent of the Antonelli matrix in production theory, compensated and uncompensated inverse supply elasticities of outputs, marginal revenue elasticities of inputs, the rate of technological change of US agriculture, and the output biases for the most important agricultural export commodities. The concept of 'relative rate of commodity progress' is defined as a means of evaluating the relative output changes in U.S. agriculture (or the evolution of the comparative advantage across commodities.) These concepts are estimated based on the parameters of the system of equations. The estimation procedure allows for the possible endogeneity of inputs and outputs and binds the distance function to conform with the regularity properties required by theory.

The paper incorporates the distance function to the international trade literature, extending and modifying the predictions of the Heckscher-Ohlin-Samuelson model and the Rybzinsky model and proceeds with estimation of the general equilibrium relations that support the notion of comparative advantage (factor supplies and technological change), productivity, and competitiveness.

TECHNICAL, ALLOCATIVE AND ECONOMIC EFFICIENCY OF FARMS IN BANGLADESH: A COMPARISON OF ECONOMETRIC AND MATHEMATICAL PROGRAMMING METHODS

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This paper derives farm-specific technical, allocative and economic efficiency estimates applying the econometric - stochastic frontier - approach and the mathematical programming - data envelopment analysis (DEA) - approach using farm-level cross-sectional survey data for rice farmers in Bangladesh and compares efficiency measures obtained from the two methods. Technical, allocative and economic inefficiency effects are modelled as a function of environmental factors, irrigation infrastructure and farm-specific socio-economic factors. The results show that there are considerable amount of inefficiency of agricultural farm production and inefficiency effects tend to be significantly influenced by the factors measuring environmental degradation, irrigation infrastructure and land fragmentation. Therefore policies leading to improving irrigation infrastructure, environmental degradation and land fragmentation could be beneficial in reducing inefficiency and thereby increasing farm output, revenue and household welfare in Bangladesh.

COMPARISON OF INDEX, NONPARAMETRIC AND PARAMETRIC PRODUCTIVITY MEASURES: NEBRASKA AGRICULTURE SECTOR

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Economists and policy makers have identified a major source of economic growth and welfare improvement of various sectors of the economy to total factor productivity. Even though the primal and dual productivity measures can be estimated by nonparametric and parametric method, the index method has been widely applied. With the recent advances in technology and application of alternative methods, it is feasible to disaggregate productivity into technical change and efficiency of the few components. Comparison of technical efficiency measures across methods has been the subject of numerous analyses with the difference attributed to the nature (deterministic or stochastic) and distribution (normal, exponential, gamma) of error term. Unlike efficiency, productivity (a ratio of aggregate output and aggregate input) comparison is built on economic theory and is hypothesized to provide similar measures independent of the method used in the estimation. Existing literature indicate the difference in productivity measures across the methods (parametric and index) and approaches (primal and dual) to their respective underlying assumptions.

Research on productivity has inclined more towards accounting for non-marketable goods even though it is hard to reconcile the hypothesis of identical primal productivity measures independent of the method. The hypothesis of identical productivity measures across methods is applied to Nebraska agriculture sector for the sample period 1936 to 1997. The index method uses the ratio between the weighted growth rate of outputs and the weighted growth rate of inputs as a measure of productivity gain between any two points in time. These weights are the partial derivatives and equivalent to one under constant returns to scale technology. Compared to the index method, the nonparametric method is built on the scalar notion of growth rate in variables and the parametric estimation minimize the sum of radial deviations between observed and realized values of the output vector. In the aggregate analysis, it is relative easy to interpret identical productivity measures across methods [index, nonparametric and parametric]. In the index approach, it is defined as the average product along the ray. In the nonparametric method, the distance function concept of scalar increase (decrease) in output (input) given technology is efficiently used in the productivity estimation. The parametric productivity measures can be computed either by estimating distance functions or estimating a production function and/or input requirement function with time trend t to capture changes in productivity.

Extension. to multiple technology is straightforward but very difficult to draw similar productivity measures across methods. An equivalency between parametric, nonparametric Malmquist and Theil Tornquist productivity index can be established provided we impose CRS and homotheticity as described by Hanoch (1970) and Forsund (1997). But if we want to prevail. over the conflict involved in the returns to scale properties, an alternative definition is the Malmquist total factor productivity index [MTFP]. MTFP, defined as the ratio of Malmquist output index and Malmquist input index is hypothesized to arrive at the same measures independent of the method [parametric or nonparametric] in the single and multiple technology and comparable to the state of art index method.

The basic purpose of the paper is to test the hypothesis of similar primal productivity measures independent of the method [Theil-Tornquist (TT'), nonparametric and parametric Malmquist total factor productivity (MTFP)] for single and multiple output-input technology.

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7C. Weights

IMPROVING ENVELOPMENT IN DATA ENVELOPMENT ANALYSIS

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Data Envelopment Analysis defines the relative efficiency of a unit using weighted inputs and outputs. The only restriction on the weights being used is that they should be positive. However, this weight flexibility can often lead to situations where some inputs or outputs may not be taken into account in arriving at the unit's efficiency measure. This paper offers an approach to try to prevent this situation arising in assessments under variable returns to scale. The approach is based on introducing unobserved units created by adjusting certain observed units. The adjustments reflect a combination of technical information and the user's value judgments.

THE EFFICIENCY OF PUBLIC FORESTRY ORGANISATIONS: A COMPARISON OF DIFFERENT WEIGHT RESTRICTION APPROACHES

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Data Envelopment Analysis (DEA) has become an increasingly popular approach to analyse the efficiency of public sector organisations. However, the underlying assumption of the method is that it is equally acceptable to specialise in producing any output or consuming any input. In many cases this kind of free specialisation is not acceptable or desirable. In this paper, we use three extensions developed to the DEA method to incorporate additional judgement into the DEA models and study the sensitiveness of the efficiency scores. The results indicate that even moderate restrictions on output weights in the optimisation problem may lead to substantial changes in efficiency.

DEA MODELS WITH NON-HOMOGENEOUS WEIGHT RESTRICTIONS

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Non-homogeneous weight restrictions in DEA are formulated as linear 'less than or equal to' inequalities with a non-zero constant on the right-hand side. Absolute weight bounds are typical examples. It has recently

been shown that, in the presence of such restrictions, the fractional linear DEA model, known as the CCR model) and its linear forms may incorrectly evaluate the maximum relative efficiency of the assessed unit. This paper suggests a way of avoiding this by replacing the objective function in DEA models by the relative efficiency of the assessed unit and converting the resulting models to linear forms. Certain classes of non-homogeneous weight restrictions, for which the replacement of the objective function is not necessary, are identified in the paper. For example, the relative efficiency is always assessed correctly if, in the same CCR model, no positive lower bounds are imposed on any of the input weights and no upper bounds are imposed on any of the output weights. The redundancy of certain types of weight restrictions in DEA models is also considered. Based on this, the traditional use of small positive constants to separate weights from zero in DEA models is questioned.

Session 8 - Sunday 31/10/99 - 9.00 – 10.45
8A. Malmquist

YET ANOTHER MALMQUIST PRODUCTIVITY INDEX DECOMPOSITION

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Recently two competing decompositions of the Malmquist productivity index have been proposed. The controversy that has arisen centers on how to isolate the contributions of technical change, efficiency change and scale economies. While the index itself is defined relative to a conical benchmark technology in order to reflect change in average productivity, its decomposition must also reflect the contribution of scale economies to productivity change. We believe that neither the initial decomposition of Färe et al. (1994) nor the subsequent decomposition of Ray and Desli (1997) have produced an economically meaningful decomposition based on both a conical benchmark technology and a data-driven best practice technology which allows for non-constant returns to scale. In this paper we offer yet another decomposition. In it we define technical change and efficiency change relative to a best practice technology which allows for non-constant returns to scale, and we obtain a pair of scale-related components, one describing the scale bias of technical change and the other describing change in scale efficiency. The empirical implications of the three decompositions are contrasted using OECD manufacturing industry data.

PRODUCTIVITY CHANGE IN SWEDISH BANKS: A COMPARISON OF MALMQUIST PRODUCTIVITY INDEXES

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This paper is concerned with productivity change in the Swedish banking industry. We apply and compare results from the Malmquist total factor productivity index (MTFP) and the traditional Malmquist productivity index (MPI). The results show that many Swedish banks experienced a banking crisis with lower productivity scores in 1990/1991; this was demonstrated using both indexes. In general, productivity change for commercial banks reached a peak in 1988/89 at about 21% and 29% for MTFP and MPI respectively, followed by another productivity regress in 1993/94. In contrast, savings banks exhibit a productivity increase in years 1991/1992 and 1993/94. Through comparison of the indexes, it can be seen that in most cases MPI is higher than MTFP although there are a few exceptions whereby they cross over one another.

IMPLICIT VALUE SHARES IN MALMQUIST TFP INDEX NUMBERS

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The last five years have seen a flood of journal articles that have used data envelopment analysis (DEA) methods to calculate Malmquist indices of total factor productivity (TFP) growth. These Malmquist DEA methods have two principal advantages over the traditional Solow and Tornqvist methods: (i) the measures of TFP change can be decomposed into technical change and technical efficiency change components, and (ii) no price information is required. There is, however, a sting in the tail of the latter advantage, because the explicit price information is replaced by implicit (or shadow) price information, derived from the shape of the frontier surface. The piece-wise linear nature of the DEA surface (and the regular occurrence of slack regions) can lead to wide variations in shadow prices (and hence value shares). In this paper we derive expressions for the value shares that are implicit in DEA calculations. We then use simple examples to help explain some of the unexpected results reported in recent applications of Malmquist DEA methods. We also use data on gross domestic product (GDP), labour and capital for 48 countries, between 1965 and 1990, to illustrate the substantial influence that assumed value shares can have upon measures of TFP growth, in particular when the capital/labour ratio changes through time.

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8B. Statistical foundation 3

A MONTE CARLO STUDY ON THE TECHNICAL EFFICIENCY ESTIMATION IN THE STOCHASTIC FRONTIER MODEL

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This study seeks to analyse some important topics related to the Stochastic Frontier Model, such as the method proposed by Jondrow et al to separate the error term into its two components and the measure of efficiency given by Timmer. With this purpose, a Monte Carlo experiment has been carried out using the Half-Normal and Normal-Exponential specifications throughout the rank of the parameter. The estimation errors have been eliminated, so that the intrinsic variability of the conditional of u given can be evaluated. Additionally, the behaviour of the mean and mode as point estimators of u is investigated.

ASSESSING MODELS IN FRONTIER ANALYSIS THROUGH DYNAMIC GRAPHICS

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One of the fundamental problems of regression analysis is judging the goodness of fit and the appropriateness of a model to the data at hand through the procedures broadly known as model validation. The same could be said of frontier analysis, with the difference that in the case of regression there is an extremely large body of techniques for this purpose, whereas no such large literature exists for the frontier approaches to efficiency measurement. This is largely due to the difficulty of ascertaining the statistical properties of non-parametric procedures (see on this the very recent account by Simar and Wilson, CORE

DP n. 9904, 1999), as well to some computational and conceptual difficulties in applying known validating procedures within parametric frontier analysis. In the present work we suggest some possible solutions to this difficult problem, through the extension of some dynamic graphic techniques proposed by Cook and Weisberg (Applied Regression Including Computing and Graphics, Wiley, New York, 1999) and by Porzio and Weisberg (Tests for Lack-of-Fit Regression Models, University of Minnesota, mimeo, 1998). More precisely, we develop upon the concepts of marginal model plot and added variable plot, in order to investigate some basic features of the estimated frontiers in simple two-dimension plots. The key insight provided by the marginal model plot is that two frontiers, whether parametric or non-parametric, are identical if and only if they coincide when projected on all their two-dimension representations. This allows for instance to shed light on the appropriateness of the convexity assumption within a non-parametric set-up by contrasting the shape of convex (DEA) and non-convex (FDH) technologies in two-dimension plots drawn in turn for given couples of inputs and outputs. Still, the shape of DEA and FDH technologies can be appraised by relying on the principal Hessian direction idea (Li, JASA, 1992) in order to find the largest possible distance among the two estimated frontiers in a projected space. Another application of the marginal model plot relates to the lack-of-fit testing procedures proposed in Porzio and Weisberg (op. cit.). Essentially, the adequacy of a model is assessed by contrasting a function of its fitted values to a fitted function suggested by the data (obtained through a non-parametric estimator). In our case, the fitted function suggested by the data is obtained by selecting a subset of efficient observations through FDH. Subsequently, this benchmark is utilised to appraise the adequacy of a parametric frontier by comparing the performance of the fitted functions on some bidimensional representations of interest (here the linear combination of outputs and inputs implied by the parametric frontier suggests at least one natural bidimensional representation). On the other hand, the main aim of the added variable plot is to yield a simple and powerful representation of the role of influential observations and of functional form assumptions in a multivariate regression set-up. Indeed, the slope of a regression line that can be drawn on an added variable plot will be the same as the slope for the corresponding regressor in a multivariate regression. Hence, the role of potentially influential observations or the appropriateness of the linearity assumption can be investigated graphically, possibly yielding precious insights about the impact of given subsets of observations on the parameter estimates. In the present work, added variable plots are used to assess the adequacy of parametric production frontiers.

STATISTICAL TESTS OF ALLOCATIVE EFFICIENCY USING DEA: AN APPLICATION TO THE U.S. PUBLIC ACCOUNTING INDUSTRY

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In 20 years since its inception, Data Envelopment Analysis (DEA) has become an important and widespread analytical tool for evaluating the relative efficiency of comparable organizations. Seiford (1996) surveys the evolution of DEA from the publication of the Charnes, Cooper and Rhodes (1978) study to the current state of art. He identifies statistical tests for efficiency evaluation as an important area for future research in DEA. While the original DEA models specify the production set relating inputs to outputs only in terms of properties such as convexity and monotonicity and do not impose any explicit parametric structure on the production set or the distribution of efficiency of individual observations, statistical properties can be derived for the DEA estimator and a variety of statistical tests can be devised if additional structure is specified (Banker 1993, 1996).

An issue that has received inadequate attention in DEA is the evaluation of allocative inefficiency in multiple output - multiple input production models. In this paper, we present theoretical work leading to new statistical tests of allocative efficiency using Data Envelopment Analysis and empirical results from the application of these new tests to the U.S. public accounting industry. We describe in this paper how a consistent estimator of aggregate technical and allocative inefficiency can be obtained and how it can be used to derive firm-specific estimates of allocative inefficiency. We show that the DEA technical

inefficiency measure using a single aggregate output variable, constructed from multiple outputs weighted by their market prices, reflects the aggregate technical and allocative inefficiency. We also provide test statistics to evaluate the null hypothesis of no allocative inefficency against the alternative of the presence of such allocative inefficiency. While such tests have been available for parametric stochastic frontier estimation methods, our paper is perhaps the first in the DEA literature to propose appropriate statistical tests for allocative efficiency.

Our empirical results have important implications for the public accounting industry. Our analysis of the data for the top 100 U.S. public accounting firms for the period 1995 to 1998 indicates that, contrary to some prior research, the public accounting industry operated under significant technical, scale and allocative inefficiencies. We also document that there has been gradual improvement in efficiency in the public accounting industry between 1995 and 1998. These findings imply that U.S. public accounting firms have not fully reaped scale economies from mergers and that they can generate significant cost savings by better utilizing their human resources.

Session 8 - Sunday 31/10/99 - 9.00 – 10.45
8C. Manufacturing application

AUTOMOBILE PRODUCTION: A SHIFT TOWARD LEANER, MORE EFFICIENT ASSEMBLY

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After experiencing a period of low output from 1959-1979, the US automobile industry reexamined its production processes and determined that worker attitudes, production methods and parts assembly had to change. The US automobile industry's Big Three, General Motors, Ford, and Chrysler, began to adopt the manufacturing practices of their foreign competitors, the Japanese. In an attempt to assemble cars at a faster pace and at lower costs, the Big Three adopted the lean production method. This method places emphasis on factory worker equality, teamwork and a low inventory-output ratio.

This paper examines the productive efficiency of U.S. automobile assembly plants operating in 1993-1995. The sample includes plants that have been implementing the lean production method and those that do not. The paper uses DEA (Data Envelopment Analysis) to compute input-saving efficiency scores for all plants in the sample. The paper overcomes data limitation problems by assessing these assembly plants using different input and output specifications relative to three production frontiers; namely, contemporaneous, pooled, and window frontiers. Selected plants that have implemented the lean production method are scrutinized to gain insights on their impact on efficiency. The results should shed some light on the worth of significant efforts and investment in the implementation of this production method.

Our preliminary analysis reveals that, car assembly plants on average are 58 to 85 percent efficient, depending on the model specifications. The frontiers are relatively stable over time. Based on very limited information, effects of lean production method on efficiency are mixed. The way in which the lean production method is implemented and the operating environment appear to be important factors affecting efficiency of the plants. This information is extremely valuable in developing a strategy to improve efficiency for US assembly plants and to enhance their ability to compete internationally.

FACTORS OF PERFORMANCE OF DAILY NEWSPAPER COMPANIES IN FRANCE

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Nicolas Romain, EJCM, Université de la Médirerranée, Aix-Marseille II, France

The press knows radical changes today: the economic and international context favours alliances, regroupings and the technological development still accelerates the changes in the sector. A new mega-industry is emerging, that of the communication, announced by many authors. This new industry will be able to provide information and leisures of all kinds, for everyone and at lower cost. The telecommunications operators, the computer companies, the editors, the studios of cinema and the television networks, like a great number of industries, are converging towards only one and even industry. Lastly, information becomes a strategic factor: the entry into the information society becomes gradually a reality.

This context has led the EJCM (School of Journalism and Communication of Marseille) to develop a research program in order to analyze the evolution of the medias and to carry out quantitative and qualitative studies. A first quantitative study of the daily newspaper companies in France has been carried out, and a model of performance evaluation of the French daily press companies realized. Thus having a general assessment of the relative levels of performances of the daily press it appears useful to seek the explanatory factors of these performances. In particular the DEA method is of major interest : it indicates, for a not very efficient company, the objectives that this company must achieve (with given resources) or it quantifies the savings in resources to be authorized (with given objectives).

The main interests of our communication will be the following:

* to our knowledge it is the first application of the DEA method to the press sector,

* the analyses which we shall carry out not only compare performances of companies but also indicate the factors of the performances,

* in conclusion we shall give some indications in order to determine the optimal strategy of the companies: either to increase the outputs, or to decrease the inputs.

Application to the press companies

The DEA method has been used to evaluate a press company with respect to its main competitors. Within the framework of this first analysis, we have retained as inputs, on the level of a press company :

the physical capital, i.e. the equipment,

human ressources; we shall consider the manpower of each company as well as the wages.

The outputs, for a press company, can be the following:

printing,

subscriptions,

advertising receipts,

turnover,

added value.

Factors of performances

A DEA analysis permits to identify for a nonefficient company the potential savings in resources; these savings are related either to the labour factor, or to the capital factor which constitute obviously the two main inputs of any process of production. In a symmetrical way the DEA method permits to evaluate, with given inputs, the objectives to be reached in terms of sales or turnover for example.

Conclusion

It appears that about half of the companies have insufficient performances. The first explanation factor is linked to capital: performances could be improved through a more sparing equipment policy. A plethoric number of employees is only the second explanation of inefficiencies. In addition, 16 companies could define higher objectives in terms of sales or turnover. In short, the savings to be made, according to the indicators selected here, should be related first to the policy of equipment, then to labour (the latter affecting in a mechanical way the wages).

FIRM SIZE, AGE AND EFFICIENCY: EVIDENCE FROM KENYAN MANUFACTURING FIRMS

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Translog stochastic frontier production functions are estimated using an unbalanced panel of 235 Kenyan manufacturing firms in the food, wood, textile and metal sectors. The sectors are estimated individually and pooled together in order to investigate whether technical efficiency is systematically related to firm size and age. The evidence suggests that firm size has a positive and significant effect in the wood and textile sectors, and also in the pooled model in which this effect becomes stronger as firms grow older. The effect of firm age is less systematic and insignificant in the pooled model and in all sectors except textiles.

Session 9 - Sunday 31/10/99 - 11.45 – 13.00
9A. Decomposition

PRODUCTIVITY GROWTH IN THE SPANISH DAIRY FARMS: A PARAMETRIC APPROACH

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The aim of this paper is to measure total factor productivity in Spanish dairy farms using a stochastic frontier approach. The data involves 410 observations from a complete panel of 82 farms observed from 1987 to 1991. In order to decompose the productivity growth into terms related to changes in technology and changes in technical efficiency, a parametric frontier production function is estimated. The technical change specification is non-neutral and the inefficiency term allows for firm-specific time-varying technical efficiency. The empirical results provide a 3.3% increase on TFP over the period, mainly due to Technical change, with a decline in technical efficiency.

DECOMPOSING PRODUCTIVITY GROWTH ALLOWING EFFICIENCY GAINS AND TECHNICAL PROGRESS

Alfons Oude Lansink, Wageningen Agricultural University, The Netherlands
Elvira Silva, Faculty of Economics of Porto, Portugal
Spiro Stefanou, Pennsylvania State University, USA

Time- and firm-specific output technical efficiency measures are generated within a price-induced technological change framework. The firm-specific production frontier incorporates long-run prices as an argument encouraging innovation and a time trend to account for exogenous technical change. The theoretical model is used to decompose total factor productivity into a scale effect, an efficiency change effect and a technological change effect. Input bias arising from exogenous technical change and price-induced innovation is investigated using a multifactor measure of biased technical change. The empirical focus is on the Dutch pot-plant firms during the 1979-95 period using the maximum entropy estimation method.

ALLOCATIVE EFFICIENCY OF TECHNICALLY INEFFICIENT PRODUCTION UNITS

P. Bogetoft, Department of Economics, Royal Agricultural University, Copenhagen, Denmark
R. Färe, Department of Agricultural & Resource Economics, UCDavis, Davis, California, USA

We discuss how to measure allocative efficiency without presuming technical efficiency. This is relevant when it is easier to introduce reallocations than improvements of technical efficiency. We compare the approach to the traditional one of assuming technical efficiency before measuring allocative efficiency. In particular, we develop necessary and sufficient conditions on the technology to ensure consistent measures and we give dual organizational interpretations of the approaches.

Session 9 - Sunday 31/10/99 - 11.45 – 13.00
9B. Size and scale

SCALE EFFICIENCY AND PRODUCTIVITY CHANGE

Bert M. Balk, Department of Statistical Methods, Statistics Netherlands, JM Voorburg, The Netherlands

Using basic principles of modern production theory, I will discuss the measurement of scale efficiency for a multi-input/multi-output firm. The next step is the combination of measures of technological change, technical efficiency change and scale efficiency change into an encompassing measure of productivity change. I will compare related proposals of Färe, Grosskopf, Norris and Zhang (1994), Ray and Desli (1997), and Grifell-Tatjé and Lovell (1998) in order to shed light on what seems to have become a controversial issue.

TECHNICAL EFFICIENCY, MANAGEMENT AND ECONOMIES OF SIZE

A. Alvarez, Department of Economics, University of Oviedo, Spain
C. Arias, Department of Economics, University of Oviedo, Spain

The study of economies of size has been an important field of research in agricultural economics. Many papers have found that economies of size exist for a certain range of output but after some level,

diseconomies of size appear, a finding consistent with the typical U-shaped LRAC curves displayed in most Microeconomic textbooks.

The reasons for the decreasing part of the LRAC are well known. If the industry is characterized by important input indivisibilities, the LRAC curve is expected to have a negative slope in all the relevant output range. Also, productivity gains from specialization of labor and management are expected to occur when firms grow, since they can subdivide tasks and become more efficient. Another factor that can also explain increasing returns to size is pecuniary externalities. Due to volume discounts on large purchases, larger farms may face lower input prices and therefore average cost may decline as farm size is increased.

But, what factors explain the rising part of the LRAC? The usual explanation has to do with management being somehow fixed: "After a point,....the firm will get so large that it will start experiencing diseconomies of scale...At this stage, production and financial economies will begin to be offset by the managerial problems of running a giant organization" (Sloman, 1998). So, the main reason to find diseconomies of size is that in many cases firms increase their size without increasing their managerial capacity. If this is the case, farms are in fact adding more variable inputs in the presence of a fixed input (management) and therefore the law of diminishing returns implies that eventually average cost starts rising.

We argue that the effect of increasing size while holding management constant is not only to cause decreasing returns to size but also to decrease technical efficiency. This idea has been anticipated by Lund and Hill (1979). "...in considering the consequences of farm's size one needs to consider both the movement along the economies of size curve and the farm's likely departure from it". And "...to the extent that the skill of the farm management on a small farm may not be sufficient to manage a much larger farm, one would expect an increase in the farm size to be accompanied by a decrease in relative efficiency".

In this paper we build a model where this hypothesis is testable and we estimate it with panel data from 85 Spanish dairy farms. An important conclusion from our specification is that modelling technical efficiency as a fixed effect can have perverse effects in the analysis of the relationship between technical efficiency and economies of size since the analysis ignores potential interactions between management and size.

ESTIMATION OF ELASTICITIES OF SUBSTITUTION AND SCALE BY DEA

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A characterization of the production possibility set in DEA based upon so-called Full Dimensional Efficient Facets (FDEFs) suggested by Olesen & Petersen (1996) allows for an estimation of elasticities of substitution and scale. This study is concerned with operational approaches for identifying all FDEFs under alternative assumptions w.r.t. returns to scale and subsequent estimation of the relevant elasticities. Preliminary numerical results are presented.

EFFICIENCY AND INCENTIVES IN REGULATED INDUSTRIES: THE CASE OF ELECTRICITY DISTRIBUTION IN SCANDINAVIA

P.J. Agrell, Department of Economics, Royal Agricultural University, Copenhagen, Denmark
P. Bogetoft, Department of Economics, Royal Agricultural University, Copenhagen, Denmark
J. Tind, University of Copenhagen, Denmark

A Stackelberg interaction model between regulated agents (decision making units) and a central regulator is presented, based on a 'best practice' regulation with actual costs reimbursed plus an efficiency bonus. In this framework, the opportunistic agents foresee their score and ecomonic reward, subject to private knowledge on the exact cost function and a limited ability to change technology. The efficiency part is calculated using Data Envelopment Analysis and ex post industry data. The particular application, distribution electric power in Sweden and Norway, offer an interesting setting through a rich data set and two complementary regulatory frameworks. The proposed model, mimicking the Norwegian DEA-regulation, gives the distributors possibility to anticipate the regulatory effect and thus to optimize their own production. Comparisions with empirical data yield insights into the dynamics of efficiency development, structural change and incentive regulation.

USING AN IDEAL NETWORK IN THE STUDY OF THE ELECTRICITY DISTRIBUTION COST IN SPAIN

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In this paper, we study the cost of the electricity distribution in Spain, using as a benchmark an *ideal* distribution network. After the introduction of competition in the generation and consumer market in Spain, the electricity distribution will be the only activity in the electricity sector under regulation. Thus, it is of interest to study the present structure of cost against the one given by a theoretical *ideal* grid. We will present a cross cost model where the cost difference will be explained by various effects. The knowledge of the origin of the cost difference should help the regulator fix the price structure in the electricity distribution.

TECHNICAL EFFICIENCY OF FINNISH ELECTRICITY DISTRIBUTION SECTOR

P. Sulamaa, The Research Institute of the Finnish Economy, Helsinki, Finland

Finland has deregulated its electricity generation and sales markets while the natural monopoly functions of the Electricity Supply Industry, transmission and distribution, remain regulated. The principal regulator is the Electricity Market Authority (EMA). The EMA aims to secure that pricing of network services is 'reasonable' as required by the section 14.2 of the Finnish Electricity Market Act. In particular, network pricing should reflect costs of providing the services. Currently there is a large degree of variation across the regional monopolies' distribution tariffs. Rather than applying explicit regulation rules, such as RPI-x, the EMA reacts to complaints on the network pricing on a case-by-case basis.

This paper presents results of an analysis of the Finnish distribution sectors' technical efficiency. The current study utilises DEA method to calculate technical efficiency scores for 1997 and 1998 data. The data consists

of the following variables for each distribution company: number of customers, amount of energy delivered, road-kilometres per distribution area, number of employees, transmission losses, line-lengths and transformer capacities. Input-oriented models with variable and constant returns to scale are used. The Malmqvist index is also calculated for the period.

Results will be reported in the meeting.

Session 10 - Sunday 31/10/99 - 14.00-16.00
10A. SFA

PRODUCTION RISK, RISK PREFERENCES, AND FIRM-HETEROGENEITY: A JOINT ANALYSIS

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This paper deals with modelling and estimation of risk preferences along with production risk and heterogeneity in the production technology. The risk preference specification proposed in the paper is general enough to test whether absolute risk aversion coefficient is increasing, decreasing, or constant. The model also allows us to identify and estimate downward risk aversion coefficient for each firm. Furthermore, the model is flexible enough to estimate and test whether distribution of production risk is symmetric or not.

We include variable and quasi-fixed inputs, labor quality and experience variables in the specification of production risk. These variables are also included in the mean output function. Thus, we separate the impact of experience and quality variables on mean output from output variance (which measures production risk). Another feature of the model is that the firm-effects in the production function (which captures heterogeneity) are separated from the firm-effects in the first-order conditions of expected utility of profit maximization. These effects can be interpreted as persistent component of allocative inefficiency (defined as the deviation of marginal product of the variable inputs from risk-adjusted input price). A panel data of Norwegian salmon farms is used as an application of the model.

SPATIAL ANALYSIS OF STOCHASTIC FRONTIER MODELS

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W.C. Horrace, Department of Economics, University of Arizona, USA.

This paper considers efficiency estimation within the stochastic frontier framework, where firm-level output (y) is a additive function of inputs (x) and a random error term composed of technical inefficiency (u) and statistical noise (v). while there are many different ways to estimate these types of models, they all hinge on an independence assumption across the statistical noise component (v). From our perspective the statistical noises can be viewed as *productivity shocks*. Given this viewpoint, it is not unreasonable to suspect that productivity shocks within a given industry may be correlated across realizations. That is, productivity *spillovers* (correlations) may exist in the statistical noise component, and the usual independence assumption across realizations of v may be violated. Theoretically, this research develops spatial econometric techniques based on geographical or economic proximity measures to explicitly test and model productivity spillovers. In the stochastic frontier specification. Using a Morgan I test statistic, we demonstrate empirically that productivity shock spillovers may exist in some data sets, at that these spillovers may have profound effects on technical efficiency estimation.

DETERMINANTS OF MUTUAL FUND PERFORMANCE: A BAYESIAN STOCHASTIC FRONTIER APPROACH

Jan Annaert, Erasmus University Rotterdam, The Netherlands
Rudi Vander Vennet, University of Ghent, Belgium
Julien van den Broeck, University of Antwerp, Belgium

Although the efficiency of financial institutions has been thoroughly studied (see Berger and Humphrey (1997) for an overview), surprisingly little is known on the efficiency of mutual funds. Research on mutual funds has been limited to establishing their risk-return characteristics and measuring their performance (or "efficiency") in comparison to one or more benchmarks. However, very few papers investigate the determinants of the thus determined under- or overperformance. Some noticeable exceptions include previous performance (Hendricks, Patel and Zeckhauser (1993), although this is controversial, see Carhart (1997)); Dermine and Röller (1992) studying economies of scale and scope in French mutual funds; Droms and Walker (1996) relating mutual fund performance to funds' characteristics in a linear regression framework.

We propose to analyse mutual fund performance using the stochastic frontier technology. This technology will be used to measure mutual fund (in)efficiency terms by relating "output", i.e. return, to several input factors, including risk measures, general expenses, and management fees. In a second step, the estimated inefficiency terms are to be explained by other fund characteristics such as size, turnover, managing institution and nationality. We use data on European equity funds provided by Micropal.

To alleviate the traditional critique on parameteric efficiency frontier estimation, that the assumption of the error term distribution is very ad hoc, we will adopt a Bayesian setting in the spirit of van den Broeck et al. (1994). In this setting the distribution of the error term is the result of the weighted pooling of the different efficiency distributions, which operation eliminates model uncertainty. Moreover, the Bayesian frontier approach directly generates estimated individual efficiencies and allows for a non-neutral shift of the frontier as well.

Session 10 - Sunday 31/10/99 - 14.00-16.00
10B. New applications

FRONTIER ANALYSIS AND EFFICIENCY OF LABOUR MARKETS IN MOROCCO

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Sergio Perelman, CREPP-Université de Liège, Belgium

The capacity of labour markets to generate new employment from a given stock of vacancies and unemployment is known as a form of transactional efficiency. It can be measured with a matching function that describes the matching process between firms and individuals. In this paper, we propose the use of alternative parametric and non-parametric frontier approaches for the estimation of a matching function in Morocco regional labour markets. The results obtained allow an evaluation of governmental employment offices (CIOPE) created in the earlier nineties to facilitate the match between the supply and demand of qualified people with a university diploma.

A PROGRESS REPORT ON USES OF DEA AND AHP FOR GUIDING PLANS FOR RELOCATING GOVERNMENT AGENCIES OUT OF TOKYO

Kaoru Tone, National Graduate Institute for Policy Studies, Tokyo, Japan

Tokyo, the capital of Japan with its population of more than 10 million persons, is suffering from serious urban and societal problems. The Diet of Japan has decided to devolve some governmental functions from Tokyo. By the end of 1998, The "Wise Men" Committee appointed by the Prime Minister selected 9 candidate sites for the new capital. It is scheduled that one site will be chosen from the 9 by the end of 1999. In this talk, I will report on this ongoing site selection problem from the point of view of methodology for consensus making among the Council members. I propose a method based on the assurance region model of DEA coupled with the Analytic Hierarchy Process in an effort to gauge where the consensus on the best sites exists. Also several DEA evaluations, e.g., evaluation from the worst side, will be utilized for this purpose.

ELECTRICITY IN AFRICA AND PRODUCTIVE PERFORMANCE: AN ASSESSMENT USING PRODUCTION FRONTIERS

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Patrick Plane, Université d'Auvergne, Clermont-Ferrand, France

Since the mid - eighties, African power companies are confronted with restructuring programs aiming notably to the improvement of the global productivity of factors through the reduction of their technical inefficiency and the elevation of the technical progress. To this end, various strategies have been adopted with different institutional choices, but always in the frame of the natural monopoly. These efforts of reform have generally been implemented through the mechanism of performance contracts. By this instrument, the government and the manager try to define and promote an adequate incentive system while maintaining the public character of assets as well as the public management. Experiences with divestiture, for example, under the form of a contract of concession signed with a private operator, were quite rare over the whole continent. In the presence of institutional monopolies, the debate on the impact of a total or partial reallocation of property rights remains a controversial topic (see Laffont, 1996). Nevertheless, a certain agreement seems to emerge highlighting the idea that privatization could be a good means to increase the level of the technical efficiency. It would contribute to strengthen incentives and control procedures, and to some extent, it would be a factor of simplification in the number of organizational objectives.

Twelve of the main African networks are studied here. Except for the Ivory company whose management has been conceded to the private sector in 1990, the restructuring experiences have been driven in a framework of public ownership.

The communication will review the aformentioned theoretical arguments in the first section. Then, we will recall what are the competitive paradigms in the art of estimating frontiers of production and measuring productive performance (Bauer,1990). Empirical analyses will occur after a brief description of the two bodies of literature. Parametric frontiers will be applied to the econometric study of a panel of observations relative to the respective periods where the twelve firms we consider implemented programs. Moreover, Malmquist indices obtained with non parametric frontiers (DEA) will be calculated for the Ivorian firm over the long run. It will enable the analysis of the performance by considering the multi-output nature of the production, economic as well as social targets, before and after privatization.

USING FRONTIER EFFICIENCY MODELS AS A TOOL TO RE-ENGINEER NETWORKS OF PUBLIC SECTOR BRANCHES: AN APPLICATION TO THE HELLENIC TOBACCO ORGANIZATION

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& London Business School, UK

In this paper we propose a methodology for assessing the feasibility of restructuring branch networks in the provision of public services. Public sector branch networks are primarily deployed over long time periods without having the flexibility of continuously monitoring and changing the size and location of public units. That is to say there is a gap between the supply and the demand of services. Furthermore, the absence of monitoring mechanisms concerning either the allocation of resources and furthermore the monitoring of the effectiveness of the provided services lead to a very serious problem: It is indeed unfeasible to draw efficiency comparisons on the basis of the cost containment minimization since many public sector branches may lack resources, provide inadequate services and at the same time yield the highest cost efficiency rating.

This problem has been the main motivation of our research which has lead to the use of an extended DEA framework whereby public units where assessed for their efficiency subject to service quality constraints concerning the effectiveness of their provided services. This was implemented by means of provided minimum feasible levels of service provision to the customers of the area under their authority. Furthermore, the DEA framework was also found useful for the assessment of the efficient levels of input resources and output generation after the restructuring of a public sector network whereby some branches had closed and their resources where transferred to the remaining ones.

The empirical results of the study were drawn from a real-life application of DEA to the Hellenic Tobacco Organisation as part of the wider restructuring plan of the organisation.

Session 10 - Sunday 31/10/99 - 14.00-16.00
10C. Efficiency theory

FUZZY PAIR-WISE DOMINANCE AND FUZZY INDICES: AN EVALUATION OF PRODUCTIVE PERFORMANCE

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Classically, the concept of efficiency measurement is based on the definition of a frontier that envelops the observed production plans. The frontier along with the required technological assumptions needed for its definition may be replaced with the concept of pair-wise dominance. This concept leads to a classification scheme for all production plans instead of a ranking based on efficiency scores. Also, the traditional assumption of deterministic or crisp production plans may be substituted with the weaker assumption of fuzzy production plans as proposed by fuzzy set theory. The fuzzy input and output variables of the fuzzy production plans are expressed in terms of their right-directed and left-directed membership functions. These membership functions represent the degree to which production scenarios are realistically plausible.

This paper presents several new approaches of ranking (comparing) production plans when they are not deterministic, but their inputs and outputs are fuzzy. The approaches are based on various comparison indices known from the literature that are used to compare fuzzy intervals. The advantages and disadvantages of the new approaches are discussed and compared to those of an existing concept of classifying fuzzy production plans.

The alternative approaches to ranking production plans developed here are also implemented for newspaper preprint insertions process (NPIP). Detailed analyses of the results are presented to describe the information available from the ranking of fuzzy production plans that can be used in conjunction with conventional DEA analysis to assess and improve the efficiency performance of the NPIP process.

BENCHMARK SELECTION: AN AXIOMATIC APPROACH

J.L. Hougaard, Department of Operation Management, Copenhagen Business School, Denmark
M. Tvede, University of Copenhagen, Denmark

Within a production theoretic framework. This paper considers an axiomatic approach to benchmark selection. It is shown that two simple and weak axioms; efficiency and comprehensive monotonicity characterize a natural family of benchmark selection procedures which typically result in one and the same benchmark selection. The latter is proved for classes of convex and freely disposable technologies.

A DEFINITION OF THE "PRACTICAL FRONTIER" IN DEA

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Data Envelopment Analysis (DEA) assigns a score to each production unit (DMU) considered in the analysis. Such score indicates whether the unit is efficient or not. For inefficient units, it also identifies a hypothetical unit as the target and thus suggests improvements to their efficiency. However, for efficient units no further improvement can be indicated based on DEA analyses. Nevertheless, it is important for management to indicate targets for their efficient units if the organisation is to improve as a whole. If the inputs and outputs of efficient units can be varied within a specified range, then it is possible to find other combinations of inputs and outputs from which new, "artificial" DMUs can be created. These DMUs are constrained to be more efficient than the DEA efficient unit from which they were created. This paper presents a linear programming model and a methodology for improving the efficiency of empirically efficient units by defining a new "practical frontier". This new frontier allows the analyst to identify adjusted efficiency scores for DMUs which were on the frontier when only real DMUs were considered. The new frontier, formed mostly from the new, artificial DMUs, thus ranks the efficient units which will now have scores less than 1.0.

Session 11 - Sunday 31/10/99 - 16.00-17.00
11B. Poster session

Education

INCLUDING NON-DISCRETIONAL INPUTS IN DEA ANALYSIS. AN APPLICATION TO SPANISH PUBLIC EDUCATION

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J. Suárez-Pandiello, University of Oviedo, Spain

In this paper we check, both, methodological and empirically, the importance of adequately including non-discretional inputs to evaluate technical efficiency. To do this, we apply Data Envelopment Analysis (DEA), a non-parametric technique largely used in the field of efficiency studies. However, there is not an agreement among the researchers about the way of including non controllable inputs in this technique, being the method developed by Banker & Morey (1986) the most used version. In this paper we have practiced two alternative possibilities: Arising from the three-step model by Fried & Lovell (1996), we suggest and run a modification that allows to reach an evaluation of the producers after compensating the effect of non-discretional inputs. To contrast the previous outcomes, we also apply the model developed by Charnes, Cooper & Rhodes (1981) for comparing programmatic efficiency. With reference to empirical analysis, the education is one of the main outputs influenced by the effects of non-discretional inputs (essentially, socio-economic and familiar status of the students), as it is noted by Hanushek (1986) or Cohn & Geske (1990). For this reason, the first aim of the analysis was to reach an evaluation of the producers' efficiency, after compensating this effect throughout the use of the three-step model. Furthermore, along the analysed years, Spanish educational sector was in an institutional transition period, due to the progressive application of a new regulation. So, a second objective was to test whether or not systematic differences in technical efficiency exist between those producers adapted yet to the reform and those that are still in transition. To do this we applied the programmatic efficiency DEA model. The results seem to show a higher inefficiency in the adapted schools. Those producers, without including non-discretional inputs, reach an average efficiency 8 % inferior to the rest of the schools. However, this value is not a consequence of a worst managerial efficiency of these producers, because when the non-discretional inputs are introduced in the analysis the average efficiency levels between the two groups are similar. Consequently, the previous differences in the efficiency levels would be based on the characteristics of the people studying in adapted to the new regulation schools, who would have a familiar and socio-economic status worst than the rest of the schools.

DEA FOR POISSON COUNT OUTPUTS

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T. J. Räty, Helsinki School of Economics and Business Administration, Helsinki, Finland

We have considered the statistical properties of data envelopment analysis (DEA) when the outputs are counts that can be assumed to have Poisson distributions. Examples of such products are degrees awarded in a university department, expensive cars sold by rural car dealerships, the number of severely ill patients that are cured during their hospital stay, or the number of persons using public transportation in a city in a day. We have applied our methods to Finnish university degrees. Earlier, it has been proposed that stochastic DEA be based on the assumption that, apart from their mean for each producer, the efficiency scores would have a common probability distribution. This assumption does not hold for Poisson like outputs. We formulate the problem in Bayesian terms and use simulation to determine the posterior distribution of the efficiency scores. A noninformative prior has been used. This leads to simple mathematics. We find that the

level of randomness is quite high when the Poisson counts have low expectations. This is confirmed by a separate analysis using Poisson regression. Our results suggest that the users applying DEA to Poisson data should acknowledge the stochasticity of the outputs, and model it statistically before drawing conclusions from a DEA.

Theory

CONTINUITY OF DEA EFFICIENCY SCORES

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An efficiency score is called "continuous" if small perturbations of the input output data cause only small changes in the score, i.e. these changes are bounded by the size of perturbations. Continuity is thus a desirable property of an efficiency score in particular in the presence of possible measurement errors and round off errors which may occur during the computation of scores. Focusing on convex technologies used in Data Envelopment Analysis (DEA) we give examples where standard radial DEA scores fail to be continuous, i.e. they "jump" under small data perturbations. We formulate necessary and sufficient conditions for input output data which ensure continuity and show that they are satisfied for "almost all" data. Moreover, we study continuity of nonradial efficiency scores and identify possible problems of the so called "two stage approach" which is often applied to compute both radial and mix efficiency. Finally, we discuss the impact of value judgement incorporated by weights restrictions on the continuity of efficiency scores.

THE ESTIMATION OF THE SHADOW COST MODEL WITH SPACE AND TIME-VARYING INPUT PRICE DISTORTIONS

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The decomposition of economic efficiency in its technical and allocative components can be performed through a shadow cost model. This can be estimated by adopting two different normalisations of the input price distortions. The former has been proposed by Atkinson&Cornwell (1994) and Kumbhakar (1996) (A&C-K), the latter by Balk (1997, following Mensah's (1994) suggestions (M-B).

The technology parameters and the cost inefficiency components obtained by estimating the two versions of the shadow cost model on the same data set are different. Besides, the estimates derived from the M-B's version are not invariant to the choice of the input price distortion chosen as the numeraire; the reason of this lack of invariance seems to be that the cost function is not linear homogenous in shadow prices and in input price distortions (Maietta, 1998) since all the input prices and the input price distortions are divided by a parameter function of other unknowns.

This means that whenever input price distortions are not constant but function of other variables, we fail to impose linear homogeneity of the cost function even adopting the A&C-K's normalisation.

Objective of the present paper is to verify if the A&C-K's version of the shadow cost model remains invariant to the choice of the input price distortion chosen as the numeraire, when input price distortions are not modelled as constants over the sample and over time. This property will be tested by estimating a model with space-varying input price distortions and a model with time-varying varying input price distortions on a panel of Italian dairy farms.

A NON-DIRECTIONAL MEASURE OF TECHNICAL EFFICIENCY

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Technical inefficiency reflects the failure of firms to obtain the maximum feasible output given the amount of inputs used. Since the seminal paper by Farrell (1957) many researchers have measured technical efficiency (TE) as the distance that separates the firm from one point in the frontier. In this sense, it is necessary to establish a direction for the firm to reach the frontier.

In the literature, some alternative directions have been used to calculate TE indexes. Farrell (1957) used the notion of radiality to select a particular direction to the frontier. Färe and Lovell (1978) indicate that there are two different radial measures of TE: output and input oriented. They give different results of TE although they are equal under constant returns to scale.

The literature on TE has considered some alternative directions. First, non-radial measures as in Kopp (1981) allow to calculate TE in a direction different from the ray to the origin. Other measures imply a specific direction such as the hyperbolic measure (Färe, Grosskopf and Lovell, 1985).

The common characteristic of these measures is that they impose a specific direction in order to measure TE. Inefficient firms are compared with one point located on the frontier. Therefore the degree of inefficiency depends on direction chosen to reach the frontier. However, an inefficient firm can improve its efficiency moving anywhere north-west of its current position.

The aim of this paper is to introduce a new index of TE that differs from previous measures in that it is not a directional measure. Actually, we suggest that TE could be calculated using the information provided by all the feasible input-output combinations that imply an improvement in the efficiency of the firm. The properties and advantages of this measure are developed in the paper. An empirical application is included to illustrate this new approach.

TRADE RESTRICTIVENESS AND EFFICIENCY

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This paper builds on sequence of papers by Anderson and Neary on index measurement of trade restrictiveness based on distance functions in price space. We introduce a 'dual' version of their index, which scales output quantities. The proposed trade restrictiveness quantity index (TRQ1) embodies two Farrell measures of efficiency, one each for the producers and the consumers. The TRQ1 has an equivalent variation interpretation in terms of index measurement of welfare changes, and can be readily decomposed into a trade distortion and domestic distortion component. Linear approximations of the TRQI are also developed to illustrate the link between the trade distortion component of the TRQI and the Anderson and Neary index, along with simple aggregate of trade distortions such as the weighted mean rate of tariff.

Agriculture

A VARIABLE DIVIDEND EFFICIENCY EFFECTS MODEL OF THE COFFEE PROCESSING SECTOR IN COSTA RICA

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This paper present the first dividend frontier model ever estimated. In this paper two literatures are merged, one dealing with the optimising cooperative, and another one concerned with the notion of production frontiers and their component efficiency measures. This study applies the resulting merged model to data describing the production activities of the Costa Rican cooperative coffee processing sector which processes around forty percent of the national production. Cooperatives in the coffee sector have a significant regional impact as they distribute the surplus of the activity among many small and medium sized farmers.

Unbalanced panel data frontier methods are used. The dataset consists of seventy-seven firm-years of observations on twenty-eight cooperatives observed for five years. The sample accounts for forty-seven percent of the total population for the study period. Then functional forms for these models are chosen by means of generalized likelihood ratio hypotheses tests. The inefficiency effects in the various models are size, degree of competition, level of development and experience. Farmer size is modelled as a restriction in production. It is shown that although the cooperative policy of free and voluntary membership does impose a cost this policy might be crucial for cooperative survival since it allows them to realize scale economies.

By means of formal tests the study finds that efficiency variation in the various models does help explain dividend variation in the sector and that this can be explained through the hypothesized explanatory variables.

INTERRELATION OF EFFICIENCY, PRODUCTIVITY AND PROFITABILITY – AN APPLICATION ON FINNISH BOOKKEEPING GRAIN FARMS

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The aim of the poster is to present both theoretically and empirically the interrelation of the concepts of efficiency, productivity and profitability. In agricultural policy the efficiency and productivity are of special interest, whereas at the farm level decision-making the profitability plays a central role, since in the long run it is a prequisite for the continuation of farming.

The profitability (a farm's ability to produce profit) is perhaps the best overall indicator of the farm performance: it measures the outcome of all management decisions including inputs used and outputs received (the underlying production technology with which inputs are converted into outputs) as well as purchase and selling prices (price relations).

The profit per unit produced (profitability) could be increased either by being able to affect the selling prices compared to input prices such that the profit increases or by making better use of physical inputs, i.e., by converting these inputs to physical outputs with increasing productivity. The change in productivity may emerge due to better use of existing resources (improving technical efficiency) or due to structural (technical) change with the use of new resources and/or withdrawal from existing resources. Technical change is often linked to an increase in the farm size.

In agriculture the prices have in most cases to be taken as given. The factor the farmer is able to affect is the allocation of inputs and outputs. Increasing allocative efficiency will also improve the profitability, although it does not necessarily increase the productivity.

The profitability of production has become increasingly dependent on the direct payments. When these payments are related to the number of hectares (or animals) they also have an influence on a farmer's decisions. In the crop production different subsidies to different crops change the relative profitability of

crops. But the acreage based support does not affect the optimal application of variable inputs per hectare, which is still determined by relative prices of inputs and outputs.

Because the profitability of production is dependent on prices as well as quantities, a high productivity does not necessarily lead to a good profitability, especially if the profitability is highly dependent on the direct payments. Although the efficient production is more profitable than inefficient, the efficiency of production does not guarantee the profitability of production.

For the empirical analysis, the profitability is defined either in absolute (the profit as such) or in relative terms (the coefficient of profitability). The productivity as a ratio of output to input quantities describes the physical performance of a farm. In this case our main interest is directed in the changes of the total factor productivity, which is measured by a nonparametric Malmqvist productivity index. This index can be devided into the change in (technical) efficiency and the technical change. The technical input efficiency is defined as a ratio of minimum feasible and observed input use when producing a given output at a given production technology. The technical (input) efficiency is defined as a Farrell type equiproportional contraction of inputs. The input cost (overall) efficiency can be defined as a ratio of minimum to observed cost of producing a given output. The input measure of allocative efficiency equals the input cost efficiency devided by the input measure of technical efficiency. These efficiency measures are also nonparametric and they are calculated by linear programming techniques.

The data consist of a panel of 55 Finnish bookkeeping farms specialized in grain production for years 1989 - 1993 (the time period before Finland joined the EU). The data were chosen following the principle that at least 50 percent of the farms' gross return (or of sales) in agriculture had to come from grains. To reduce the yearly stochastic variation, moving averages of three years were applied.

The data do not include farmwise input and output quantities or prices in addition to costs and returns (the labour and land as exceptions). Therefore, the analysis requires as a basic assumption that the prices are the same over the farms. For the nonparametric analysis one output (gross return) is defined. Labour and land can be measured either in physical quantities or in monetary terms. Machinery and buildings are kept separate inputs as well as fertilizers, other cultivating materials and energy. These inputs are recorded in monetary terms. Machinery and buildings are measured as service flows including depreciation, real interest rate, maintenance and rents paid.

Values of economic indicators vary over the farms but they vary a lot also between sequential years at the same farms. The rank correlations within a year between the technical and the cost efficiency, the allocative and the cost efficiency, and the cost efficiency and the coefficient of profitability were high (0.74 - 0.87). Instead, the correlation between the technical and allocative efficiency was low. The correlations between measures d ecreased markedly when the time period got longer.

From 1990 to 1992 (moving averages), the average total factor productivity decreased due to a fall in technical efficiency. The effect of technical change was close to zero during this period. The profitability fell also at the same time. As expected, even a small decrease in efficiency causes typically a relatively large change in profitability. The decrease in productivity results e.g. from the weather conditions and increasing area of set aside, which affect the quantities produced. The simultaneous fall of product prices shrinked also the profits.

When looking at the changes in the measures of performance from 1990 to 1992 the rank correlation was highest between the change in cost efficiency and in the profit (the surplus of gross return minus cost of inputs mentioned above, excluding land) per hectare (0.76). The change in total factor productivity had its highest correlation with the profit/ha (0.60) and the change in technical efficiency (0.50) and the lowest with the change in allocative efficiency (0.12). The change in cost efficiency correlates also strongly with the change in allocative efficiency (0.62).

Although the correlations were in many cases relatively high, large differences in indicators also occured. As an indication of this, the cost efficiency increased or stayed the same in 15 of 55 cases, the profit/ha in 11, the total factor productivity in 16 cases and the technical efficiency in 18 cases. However, there was a simultaneous increase (or no change) in the profit per hectare and the cost efficiency only in 7 cases and in 9 cases there was an increase both in the profit per hectare and the total factor productivity. Both the technical efficiency and the profit per hectare increased in 10 of 55 cases.

The link between productivity and profitability is weakened when the share of direct payments in gross return increases. Low output prices compared to average variable costs are likely to reduce the incentive to produce. In the future, farmers may often face the situation where they maximize the profit by minimizing the losses of production.

Productivity

NONPARAMETRIC CONTINUOUS TIME PRODUCTIVITY MEASUREMENT BASED ON DISCRETE DATA

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This paper develops a framework to measure productivity change and its components in relation to a nonparametric (DEA-type) continuous time frontier representation of technology estimated by linear interpolation between discrete data. The components considered are change in technology and technical efficiency, change in allocative efficiency and changes in prices. Each component is represented both by a measure of relative contribution to the total productivity change and by a vector movement in the relevant space. The novel productivity measurement technique is contrasted to established, discrete time, index measures of productivity change (e.g. Malmquist productivity indices). Arguments in favor of the continuous time approach are supported by theoretical considerations and numerical tests with real and simulated data.

AN ANALYSIS OF PRODUCTIVITY IN IRAN

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This paper is suppose to identify the main factors of influencint the non oil GNP growth rate in Iran. A model based on theory, has been formed consisting of non oil GNP, inflation, oil price, the growth rate of population and an index measuring the effects of productivity on the growth rate of GNP. An econometric model was estimated an inspected with different assumptions. The result shows the effect of productivity determining the time pattern of non oil GNP is quite high and unstable. There are many factors which may explain the nature of fluctuations, such as, lack of skilled labour, management abilities and shortage of foreign exchange due to fluctuation of government oil revenues. This paper also investigate the impact of Iran-Iraq war on the time pattern of most important relevant variables.

COST EFFICIENCY OF JAPANESE ELECTRIC UTILITIES BEFORE AND AFTER REGULATORY REFORMS IN 1995

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Cost efficiency of nine Japanese electric utilities is estimated to investigate whether there was a shift towards optimal production after a series of regulatory reforms in 1995. In 1995, the Electric Utility Law has been amended, enabling Independent Power Producers (IPP) to enter into electricity generation business via competitive bidding. At the same time, yardstick regulation was introduced into the traditional rating system to facilitate inter-utility competition and to reduce their capital costs. Fule cost adjustment clause is also introduced. These reforms put increased competitive pressure on incumbent electric utilities, particularly on fossil fuel generation, encouraging efficient production. On the other hand, some of the reforms are directed to cost of particular inputs, which may induce distortions in input choice (allocative inefficiency). Our model is a direct application of Balk(1997) and translog cost function system is employed to estimate input technical efficiency and input allocative efficiency. The result suggests that so far there is no significant impact on cost efficiency from the series of regulatory reforms in 1995.

PRODUCTIVITY, R&D CAPITAL, AND PUBLIC INNOVATION SUPPORT; THE CASE OF DANISH MANUFACTURING

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The purpose of this paper is to investigate the relationship between productivity and R&D capital in Danish manufacturing. The main conclusion is that the elasticity of output with respect to the knowledge of stock attains a value around 0.1. We also investigate whether there is a relationship between R&D capital and public innovation support. It is found that public innovation is weekly exogenous and has a positive effect on R&D capital, implying an indirect positive effect on productivity. The magnitude of this effect is an elasticity of the knowledge stock with respect to public innovation support of 0.04. Moreover, public innovation support seems to facilitate the transformation of knowledge developed by firms performing R&D into technology improvements.

The applied model is composed of two building blocks: production function for manufacturing goods and knowledge and the relationship between R&D capital and institutional conditions such as the availability of human capital, information and the communication technology infrastructure, market structure and legislation.

The estimation period in the analysis is relatively short, namely the period 1968-1997. In order to evaluate the estimated elasticity of manufacturing output with respect to the knowledge stock a panel data set of 5 sub-sectors of the manufacturing sector are constructed from 1973 to 1995. The estimated elasticity using this panel data set is in line with the estimated for aggregate manufacturing output.

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