
BOOK OF
ABSTRACTS

M1-1 AGRICULTURE I

Chair: Maria Vrachioli

ABSTRACT Nº: [175] - TECHNICAL EFFICIENCY OF CROP FARMS IN THE EUROPEAN UNION – A METAFRONTIER APPROACH

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The aim of the study is to compare technical efficiency of crop farms between regions and countries of the European Union. We employ the metafrontier approach based on two alternative methods, i.e., deterministic Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). Most studies based on SFA estimate the metafrontier using a two-step procedure. However, we follow the one-step procedure, which has been recently developed and employ Bayesian approach in order to estimate the parametric metafrontier. In the SFA approach the technical efficiencies of the analysed crop farms (aggregated by regions and size classes) are similar when their efficiency is measured with respect to the country-specific frontier (group frontier). However, the estimates of metatechnology ratios (MTR) (i.e., the distance between the country-specific frontier and the metafrontier) reveal significant differences between European countries. Consequently, the metafrontier technical efficiency scores (i.e., the efficiency of crop farms from a particular region relative to the metafrontier) differs between regions of the EU. The results obtained with the DEA approach, unlike the SFA approach, show significant differences between the group-specific efficiency scores, while the MTR are similar to the ones derived from the SFA approach. The eventually received metafrontier efficiency rankings of the crop farms based on the alternative approaches (DEA and SFA) are similar. In particular, the results indicate that crop farms from the "new" Member States of the EU are still less efficient than those from the "old" ones (the EU-15 area).

ABSTRACT Nº: [226] - CLOSING ENVIRONMENTAL EFFICIENCY GAPS OF RICE PRODUCTION: EVIDENCE FROM CHINA

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Environmental efficiency gap (differences across farm sizes) analysis is a vital strategy to achieve sustainable intensification in agriculture, as it is relevant to synergies between high yields and low environmental pollutants. Previous studies mainly focus on yield gaps in developing countries where agricultural landscape is smallholders based, but little consider environmental problems caused by yield growth due to increasing input use intensity, raising concerns regarding the environmental sustainability of increased productivity. Research related to environmental performance often assumes farms share the same production technology, preventing from informing policy making in the context of closing efficiency gaps between smallholders and large estates. Using country-representative survey data from rice farmers in China during 2014-2018, we first specify group-specific hyperbolic distance function to

estimate farm-level environmental efficiency of small-, medium- and large-farms. Nitrogen loss is considered a detrimental output. Second, we estimate a stochastic metafrontier to determine the technology gaps regarding environmental performance. Using these approaches, we contribute to the literature by comparing cross-size environmental performance and exploring potential avenues to close environmental efficiency gaps. Our results show that there is a scope to improve farm-level management performance in all producer groups and most pronounced for smallholders. We also find technical training, cooperatives, growing experience and education benefit efficiency, while production subsidy has a negative impact on environmental performance. Results estimated by enhanced hyperbolic distance function evidence contraction of input is an effective way for technology catch-up.

ABSTRACT Nº: [49] - ARE EUROPEAN FARMS EQUALLY EFFICIENT? WHAT DO REGIONAL FADN DATA ON CROP FARMS TELL US?

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The goal of the research is to analyse the efficiency of 440 crop farms which are spread across 99 regions in 24 EU countries. In order to do this, we first recall the standard stochastic frontier (SF) models, i.e., with normal-half-normal and normal-exponential composite error term, which are useful workhorses for efficiency and productivity analysis nowadays. We find that residuals derived from the above-mentioned production models are positively skewed, which is predominantly interpreted as lack of inefficiency or, in other words, full – or almost full – technical efficiency. Here, this initial finding is reaffirmed using a formal Bayesian model comparison framework, as we find that there is Bayes Factor (BF) support for the lack of the inefficiency (the natural log of BF in favour of the regression model without the inefficiency term is 5.295 against normal-half-normal and 9.163 against normal-exponential SF specification). This is an obvious culprit of the entire analysis as these results appear to be in contrast with common knowledge about the production process in the agriculture field. To this end, the conclusion would be that the models used so far fail to detect the underlying inefficiency of the analysed process. Usually, we would start redesigning the technology frontier or rethink the choice of variables, or both, in order to 'persuade' the residuals to behave properly, i.e., to have 'proper' skewness under the standard stochastic structure of the model. However, the parametrization of our production frontier is fairly standard and quite well established in the literature. Hence, we look at the 'wrong skewness' problem in a different way, that is, as being an artefact of an over-restrictive assumption about the compound error term in standard SF specifications. We deal with this problem – and thus with the unfeasible full efficiency it produces in our research – by applying the generalized t-generalized Beta of the second kind (GT-GB2) SF model framework, which is the most generalized parametrization of an SF model up to this date. Based on the GT-GB2 model and using formal Bayesian model comparison techniques we find that t-half-generalized t model is the best model from a range of potential models supported by the data. The logged value of Bayes Factor in favour of this specification is 59.483 against the notion of equal efficiency, which from the empirical point of view clearly indicates that there is indeed substantial efficiency variation among different farms – just not the kind that could be captured with standard SF models. We note that other relevant GT-GB2 model simplifications also indicate similarly substantial inefficiency. Hence, it would seem that

at least in some cases – such as the one found in this research – the wrong skewness problem can be viewed as the consequence of too restrictive assumptions about the compound error in standard SF model.

The t-half-generalized t model indicates average efficiency of about 0.826 (0.102) and, interestingly, a relatively uniform spread of efficiency scores within the minimum and maximum range. We find that, on average in the analysed period, the least efficient farms around found in Slovenia (0.797) and Poland (0.802) while the most efficient ones are in The Netherlands (0.888); other highly efficient regions for crop farming are found in Belgium, Denmark, Spain and Italy. In terms of temporal dynamics we find that Danish farms gained on efficiency quite substantially in the analysed period while farms in Poland and Malta fell behind.

ABSTRACT Nº: [78] - WATER IN PESTICIDE APPLICATION AND RATIONAL INEFFICIENCY: THE CASE OF SPANISH CROP PRODUCERS

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Agricultural activities can be characterized by inefficient use of production factors, including water. This study assesses to what extent this inefficient use of water and pesticide can be attributed to farmers' rational decisions and whether these rational decisions could lead to water externalities from pesticide pollution.In this study, we adopt the production function approach where each arable crop producer uses a vector of inputs, including water for pesticide application, to produce a single output, which is an aggregate output index of cereal, oilseed and protein crops. Each producer's technical efficiency score is then estimated using the Data Envelopment Analysis (DEA) model which also accounts for production risk through a state-contingent approach (bad, normal and ideal states of nature). The application focuses on a sample of 148 Spanish arable crop producers in Catalonia. For the rational inefficiency hypothesis to be tested, we developed and assessed 4 assumption groups regarding the magnitude of inefficiencies and the amount of water used for pesticide application (measured in liters/ha). Crop producers with water use for pesticide application and efficiency scores below the median were categorized as the rational inefficient group. The producers who applied relatively low levels of water for pesticide use but attained high levels of efficiency form the multi-efficient group. Crop producers with low efficiency and high levels of water use for pesticide application appear to adopt a technical inefficient behavior. Finally, producers with both high efficiency and high water application for pesticide use were viewed as being technical efficient. To assess the hypothesis of rational inefficiency among the Catalan arable crop producers, a comparison between the rational inefficient group and the technical efficient group needs to be performed. The rational inefficient group on average had lower values of technical efficiency scores and lower amounts of water used for pesticide application compared to the technical efficient group. This pattern also holds under the three different states of nature, where the technical efficient group performs better than the rational inefficient group, while using more water for pesticide application. In addition, our results reveal that the producers belonging to the rational inefficient group had significantly higher values of pesticide pollution compared to the other three groups. These high levels of pesticide pollution in the rational inefficient group indicate that these producers are choosing to use less water for pesticide application, but they also exhibit elevated levels of pollution from pesticide application. This can be interpreted as a potential situation of rational inefficiency among crop producers associated

with environmental externalities. Based on the results of this study, some of the crop producers may experience lower efficiency scores due to the limited use of water for pesticide application, which could be further associated with higher levels of pesticide pollution. Given that all producers are profit-maximizing oriented, the low performance of the rational inefficient producers in comparison to the technically efficient producers may not only be attributed to poor production decisions (limited use of water), but also to diminished land and water quality (or even ecosystem degradation) due to pesticide pollution on their fields over the years.

M1-2 TRANSPORT

Chair: Soraya Hidalgo Gallego

ABSTRACT Nº: [145] - A BENCHMARK APPROACH FOR EFFICIENCY IMPROVEMENT IN GREEN SUPPLY CHAIN MANAGEMENT WITH DEA MODELS

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Nowadays, concerns about environmental issues are increasing. So, companies and producers are under pressure of the government rules and regulation from one side, on the other hand, maintaining customer satisfaction that cares about environmental concerns like global warming and emissions are vital in this age of competition. Green Supply Chain Management (GSCM) is a procedure to increase efficiency and environmental effects for companies that collaborate with customers and suppliers. According to GSCM, the companies should apply green purchasing, green design, green manufacture, green distribution, green packaging, green marketing, and reverse logistics to improve their performance about environmental issues. Also, recently, Data Envelopment Analysis (DEA) as a nonparametric model is used to evaluate Decision-Making Units (DMUs) efficiently in supply chains. So, evaluating for choosing the best possible GSCM performance is vital and DEA models can apply for this purpose and, help to choose the best supplier for organizations by considering the green supply chain principles which important to the factories to reach the better performance on the whole supply chain. This study developed a benchmark approach for evaluating the efficiency of green supply chains. Here 38 DMUs are evaluated by DEA standard models and the efficient DMUs consider as benchmarks. These benchmarks (9 DMUs) are used for the improvement of inefficient supply chains which have the potential to be efficient by slight adjustment and modification.

ABSTRACT Nº: [125] - NON-PARAMETRIC EFFICIENCY ANALYSIS WITH UNOBSERVED INPUTS IN MULTI-OUTPUT SETTINGS

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Traditional methods for performance measurement crucially depend on the assumption that all input factors are fully observed by the analyst. Under the presence of intangible assets (like automation or digitization) this assumption is likely not to be met, thereby creating the potential for omitted variable bias in performance benchmarking. Moreover, within the literature the issue

has been raised repeatedly to measure performance of multiple production processes simultaneously, which involves modelling how inputs are linked to (subgroups of) outputs. The current paper accounts for these concerns by extending recent work of Cherchye et al., 2018, 2021 to introduce a novel, non-parametric method tailored to measuring cost efficiency at the individual output level while a subset of inputs remains unobserved to the analyst. Our approach is robust to endogeneity issues, accounts for scope economies and reports output-specific cost efficiency scores (even if only limited information on input allocations is available). We illustrate the applicability of the method through an application to a purpose-built dataset on Belgian railway traffic control rooms.

ABSTRACT Nº: [124] - PREPARING TO GO PUBLIC! PRODUCTIVITY DECOMPOSITION FOR SPANISH STATE-OWNED AIRPORTS AFTER THE GREAT RECESSION

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This article analyses the total factor productivity decomposition of aeronautical activities for the Spanish airports for the period before of partial privatization (2009-2014). To do this, we use the estimates of a short-run variable cost model (Núñez-Sánchez et al., 2020) that allows disentangling scale, technical change, the quasi-fixed input change and a markup component. We follow the methodology of Kumbhakar and Lozano-Vivas (2005).

In 2010, the Spanish government created Aena Aeropuertos in order to provide greater flexibility to the system. Individualized management of airports through the creation of subsidiary companies or concession contracts was contemplated for Madrid and Barcelona airports. However, the administration elected in 2011 canceled auctions for the concession of those airports. A new reform in 2012 tried to adjust airport charges to their market value progressively. In 2013 an airport efficiency plan aimed to improve the performance of regional airports. In February 2015 Aena Aeropuertos was partially sold through public offering. Aena achieved in the first year of its IPO a revaluation of 65%.

We use a balanced panel data for 35 Spanish airports observed yearly from 2009 until 2014 considering the period before of partial privatization. The economic and financial information was obtained from the annual reports published by Aena, which provides accounting data that is both homogeneous and comparable across the airport system. Additional statistical data have been gathered from the Spanish National Statistical Institute (INE). The final panel data set consists of 210 observations.

The variable cost is the sum of labor and intermediate consumption expenses. Regarding outputs, we consider two output variables: number of passengers and volume of operations (measured as their maximum take-off weight in tons) since the two main aeronautical charges relates directly to them. On the one hand, Aena charges its landing services using the maximum take-off weight in tons as the unit of measurement for the volume of operations. On the other hand, passenger output variable is measured as the number of passengers using the airport facilities. In order to calculate the markup component, it is necessary to consider passenger charges and landing charges. On the input side, we have considered three inputs: two variable and one quasi-fixed input. The variable inputs are labor and intermediate consumptions,

whereas the terminal surface measured in square meters approximates the quasi-fixed input. We have computed labor price as the annual cost per worker in the storage sector and support activities for transportation (in which airports are included) from the Annual Survey Labor Cost, published by the Spanish National Statistical Institute (INE). Regarding the price of intermediate consumptions, the regional-level Industrial Price Index is used as a proxy.

The results show that the mean TFP growth from the parametric econometric model is 4.3% per year. The highest TFP growth corresponds to those airports specialized in tourism. The lowest TFP growth corresponds to regional airports. TFP growth is positive from 2011 to 2014, driven, primarily, by the existence of technical change. The successive reforms implemented by Aena may explain this result. The scale component contributed negatively to TFP growth. This is especially true for airports located in mid-sized cities, some tourist destinations and regional airports. The relative contribution of the quasi-fixed input change or the markup were negligible.

ABSTRACT Nº: [146] -THE EFFECT OF INVESTMENT ON PORT INFRASTRUCTURE PROVIDERS´ COST EFFICIENCY: A CASE OF STUDY FOR SPANISH PORT SYSTEM

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Studies that analyse the efficiency of the port industry form a significant part of the academic analysis of the port sector. A growing body of studies within this literature assesses the likely determinants of port efficiency. The most studied determinants of port efficiency have been containerisation and specialisation, private property and private participation in port operations, hinterland conditions, or the port's size. However, to the best of our knowledge, no study directly estimated the effect of investment on port efficiency despite the importance of investment decisions within port management. Therefore, this study aims to fill this gap by estimating the impact of investment on Spanish port authorities cost efficiency for 2000-2018.

In the Spanish case, Spanish port authorities have autonomy in planning their investment, subject to their economic results. This led to Spanish ports carrying out great investments regarding the financial resources involved and expanded capacity and infrastructure. During the period evaluated, Spanish port authorities' investment expenditure has surpassed 11,678 million euros, mainly in infrastructure and capacity expansion (51%), equipment and commodities (10%) and logistic activities and intermodality (7%). Then, it seems crucial to know if these resources have helped reduce port authorities operating costs and improve their cost-efficiency.

In this research, port cost-efficiency and investment's effects are estimated in a one-step procedure following the True Fixed Effect (TFE) methodology (Greene, 2005). This approach separates time-invariant heterogeneity among agents from the inefficiency component. A translog total cost stochastic frontier is specified concerning the frontier specification. The error term of the stochastic total cost frontier is composed of the random disturbance identically, independent, and normally distributed with zero mean; the firm-specific effects; and the inefficiency term assumed follows a non-negative truncated normal distribution. Finally, investment is supposed to impact inefficiency by the mean of its distribution (Belotti et al., 2012).

The dataset used for analysis consists of 26 Spanish port authorities observed during 2000-2018. Five outputs have been considered: liquid bulk, solid bulk, containerised general cargo, non-containerised general cargo and passengers. Regarding the prices, the model includes the prices of three variables inputs, labour, capital and intermediate consumption.

As the factors affecting cost-efficiency, this study considered, on the one hand, the total investment. On the other hand, we have separately considered the different types of investment: investment in capacity and infrastructure, equipment and commodities, logistic activities and intermodality, and other investments.

The preliminary results show: 1) there is a cost adjustment after 2008, likely produced by the economic breakdown of that year. 2) When total investment is included in the model as a cost efficiency determinant, there is not a significant effect of investment on cost efficiency. 3) However, the model shows that capacity and infrastructure investment positively affects cost-efficiency. 4) The estimation of the marginal effects (Wang, 2002) suggests that the efficiency gains produced by investing in capacity and infrastructure are higher at the lower levels of investment, presenting decreasing marginal gains.

M1 - 3 SFA APPLICATIONS I

Chair: Maria J. Perez Villadoniga

ABSTRACT Nº: [22] - SELECTIVE COLLECTION AND EXTERNAL ENVIRONMENTAL FACTORS IN COST EFFICIENCY. AN APPLICATION TO SPAIN

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In recent years, many studies have analyzed efficiency in local governments (Narbón-Perpiñá and De Witte, 2018a). Specifically, waste management service has been one of the most studied services in this context (Narbón-Perpiñá and De Witte, 2018b) due to its economic and environmental importance.

Indeed, nowadays local governments have significantly revised their environmental policies, in response to a worrying increase in the generation of municipal solid waste (Guerrini et al., 2017). The growing amount of waste disposed in landfills is a great concern for public policy makers, and recycling is considered the way to solve this problem (Kinnaman, 2006). In this context, new EU guidelines support the selective collection of municipal solid waste (Ferreira et al., 2017). However, this process is usually related to higher costs, due to the need of infrastructure adjustments, a greater number of workers or collecting vehicles, among others (Lavee and Nardiya, 2013; Carvalho and Marques, 2014). So, the analysis of waste management cost efficiency is essential in this context (Bel and Fageda, 2010; Benito-López et al., 2011; Simões and Marques, 2012). In order to determine how the selective collection may affect to local government efficiency (Campos-Alba, 2021).

Moreover, the management form of local government service delivery adopted can play a decisive role. In this sense, previous literature has studiedwhich management form of local government service delivery provide the highest levels of efficiency (Goodspeed, 2017; Srakar

et al, 2017; Zafra-Gómez et al., 2018). Traditionally, the debate was focused on the opposition of public and private management forms (Dijkgraaf and Gradus, 2003; Bel et al., 2010; Simoes and Marques, 2012; Simoes et al., 2012a; 2012b; Suárez-Valera et al., 2017). However, new management forms have proliferated and now, the range of management forms is very extensive so public managers can choose from diverse alternatives. Among these alternatives, different types of joint service provision, such as intermunicipal cooperation (Hefetz and Warner, 2012; Bel, Fageda and Mur, 2014) has become in a tool of reducing costs in the provision of municipal services (Bel and Fageda, 2006, 2008a; Mohr, Deller and Halstead, 2010), especially in smaller municipalities taking advantage form the economies of scale.

Additionally, the provision of municipal waste management is influenced by the characteristics of the environment in which the municipality is located and where the service is provided. So, to assess efficiency, it is necessary to considerate certain environmental constraints that cannot be controlled by municipalities and that may have a significant influence on service efficiency (Badin et al., 2014; Schiltz et al. 2019, Pérez-López, 2021), such as population density.

So, the objective of this study is to analyze the cost efficiency of municipal waste management considering the selective collection of waste and the different service management for a sample of 705 Spanish local governments. It is proposed a two-step analysis by assessing, in the first stage, the cost efficiency by a parametric cost multiproduct function conditioned by external environmental factors. In the second stage, the efficiency of the diverse management forms (public, private and joint formulas) will be studied.

ABSTRACT Nº: [53] - THE PRODUCTIVITY EFFECTS OF SUPPLIER, BUYER AND COMPETITOR DRIVEN INFORMATION AND COMMUNICATION TECHNOLOGY SPILLOVERS

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Apart from the direct impact that information and communication technologies (ICT) may have on firm productivity, they may also have indirect effects on non-investing firms (Brynjolfsson and Hitt, 2000). For instance, investment in ICT improves intermediate inputs that are subsequently used by non-investing firms downstream in the value chain. Similarly, non-investing firms can benefit from new knowledge on ICT-enabled innovations and practices gained through repeated interactions with firms that use digital technologies (Han et al. 2011). Spillover effects from ICT, have been the subject of previous research, but we still have a rather poor understanding of the relevance of these spillovers and the underlying mechanisms. Moreover, the evidence is rather inconclusive and conditioned by insufficient data availability.

In this study, we first estimate an augmented production function that considers both ICT capital and non-ICT capital at the firm level. To estimate total factor productivity (TFP), we use a control function approach version of Wooldridge (2009). Second, we analyze the effects of ICT spillovers on firm productivity by distinguishing between two dimensions, vertical and horizontal. Previous studies have tended to focus solely on one of these two dimensions. However, not only can the sign and the magnitude of these effects differ, but so can the mechanisms at work. For example, while finding a negative horizontal spillover may be the result of a business stealing effect from product market rivalry (Bloom et al., 2013), this mechanism is not a plausible explanation for a negative vertical spillover. Similarly, vertical

spillovers stemming from suppliers are of a different nature from those originating from buyers. For instance, improved intermediate products may benefit firms downstream (Cheng and Nault, 2007), but not upstream. Therefore, by distinguishing these three types of ICT spillovers, we can explore the different dimensions of the concept and its causes, thereby contributing to a better understanding of the mechanisms. This is important if we want to fully understand the returns to ICT and provide advice to managers and policy makers.

The study is performed over a large and representative sample of Spanish manufacturing firms. Contrarily to previous studies, which have focused on large firms and short time windows, our sample includes firms with 10 or more employees and uses data on the period 1991-2014. The dataset provides information on firm investments in ICT and non-ICT capital, which is a clear advantage compared with recent papers on the topic (Marsh et al., 2017), given that it allows us to isolate the direct and the indirect effects of ICT investments. In order to measure the effect of ICT spillovers on firm productivity, we use data on trade flows between industries provided by the WIOD database, while data on industry ICT investments are taken from EU KLEMS dataset. This exploration takes place by exploiting the heterogeneity of firms across size of the firm and degree of digitalization of the industry (Calvino et al., 2018). Finally, it is important to stress that we address the problems of endogeneity and heterogeneity through the use of state-of-the-art methods, such as the ones proposed by Levinsohn and Petrin (2003) and Wooldridge (2009).

Our results show that the output elasticity of ICT is smaller than that of non-ICT capital; and differs among firms. The elasticity is larger for large firms, for those in highly digitalized sectors and for firms with R&D activities. Second, out results show that, overall, ICT spillovers have a positive impact on firm productivity. However, they suggest that not all the firms benefit equally from ICT spillovers. When we distinguish between low vs high digitalization industries, we find that the average firm only benefits from ICT spillovers in industries characterized by a low digitalization.

ABSTRACT Nº: [158] - NONPARAMETRIC ESTIMATION OF TECHNICAL CHANGE IN NORWEGIAN FIRMS

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In this study, we investigate technical change in Norwegian firms. We use accounting data collected by Statistics Norway and it is an unbalanced panel for the period 2000 – 2018. We follow the novel approach introduced by Kumbhakar et al. (2021), to formulate and estimate technical change nonparametrically without estimating the underlying production technology. Further, we make behavioral assumptions on profit maximization. Hence, technical change is formulated by using the first-order condition of profit maximization. Our empirical results will increase knowledge on the development in technical change in Norwegian firms, and give insight on factors explaining technical change and their marginal effects. The results will be presented at the workshop.

ABSTRACT Nº: [185] - INNOVATION AND EMPLOYMENT

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Investing in innovation is one of the most important decisions made by firms: process and product innovations affect firm growth and future competitive advantage, as well as employment outcomes.

Innovation affects not only total employment, but also the composition of employment, and this effect will depend on the nature of the innovation. In contrast to the skill-biased technological change hypothesis, new theories suggest that task-biased technological change is taking place. According to this theory, computers are good at performing routine tasks, but more limited at performing abstract tasks, associated with high levels of education, or manual tasks, which require little formal education. In line with the predictions of this hypothesis, evidence in several countries suggests employment increases in occupations requiring high and low skill levels and decreases in jobs requiring intermediate skills.

We analyse the effects of innovation on employment outcomes. In particular, we distinguish among process, product and business model innovation and examine whether different types of innovation activities have a differential impact on the composition of employment.

To this end, we propose to estimate the production technology of a sample of manufacturing firms in Spain. We use data provided by the Encuesta de Estrategias Empresariales, an unbalanced pannel of firms observed between 1990 and 2016. The sample includes information on firm's output, inputs, R&D expenditure, innovation activities and composition of employment.

We will estimate a production frontier and apply duality to obtain the optimal demand for different types of labour. This will allow us to evaluate how the demand for different types of labour is affected by the type of innovation carried out by firms.

M1-4 MULTI-METHODS I

Chair: Mohsen Afsharian

ABSTRACT Nº: [176] - A COMPARISON OF DATA ENVELOPMENT ANALYSIS, STOCHASTIC FRONTIER MODELS AND MODEL COMBINATION APPROACHES USING PANEL DATA.

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Agencies that regulate local, natural monopoly markets often apply nonparametric data envelopment analysis (DEA) and stochastic frontier analysis (SFA), as well as combinations of the two approaches. Even though they have access to panel data often they often use simple averages of a few years which they then treat as cross-sectional data. These methods have been evaluated recently in simulation studies and it is shown that they often underestimates

the true efficiency values. This paper aims to investigate, using Monte Carlo simulations, panel methods for SFA and DEA but also suggest model combinations of them. This will be compared with the simple averaging approaches currently used. The data will be generated according to a panel data stochastic frontier model that allows for both persistent and transient inefficiencies along with random firm-effects and statistical noise. Based on the result from the simulation study we will give guidelines to regulators regarding which method that can be used. Finally, we illustrate the methods using data from the Swedish energy market inspectorate where we have access to data for more than 20 years for around 150 firms.

ABSTRACT Nº: [133] - A NEW APPROACH TO ESTIMATE TECHNICAL EFFICIENCY BASED ON ONE-CLASS SUPPORT VECTOR MACHINES

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In this paper, a new unsupervised machine learning-based approach is introduced to estimate production frontiers. The method satisfies basic axioms of microeconomics in production theory, such as convexity and free disposability, but it does not meet minimal extrapolation; which is the cause of overfitting in the case of applying standard methods as Data Envelopment Analysis (DEA). Additionally, the new approach can be seen as a generalization of DEA and is based upon One-Class Support Vector Machines with piecewise linear transformation mapping. It is also shown how to measure technical inefficiency through the directional distance function under the new approach. Finally, we evaluate the performance of the method through a computational experience.

ABSTRACT Nº: [202] - STATE-CONTINGENT PRODUCTION TECHNOLOGY: MAPPING PRODUCTION UNCERTAINTY USING REDUCED-FORM MODELS OF CROP YIELDS

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The state-contingent approach presents a consistent conceptual framework for analyzing producer decisions under production risk and other sources of uncertainty. To date, however, relatively few empirical applications of this approach exist in the literature. An important aspect of the empirical implementation of the state-contingent approach is the consistent mapping of producers´ stochastic outputs to uncertain events in the context of multiple-output production. Applying consistent mapping rules is particularly critical in panel data analyses when the effect of uncertainty may be confounded by producers´ unobserved heterogeneity. This paper presents an empirical strategy for formulating states of nature in the context of a multiple-output production, using reduced-form models of crop yields. We show that the proposed strategy respects the panel data structure and allows accounting for farm unobserved heterogeneity. The model estimation results, obtained using Hungarian farm accountancy data, show that the technology employed by Hungarian cereal producers permits substitutability between state-contingent outputs.

ABSTRACT Nº: [151] -THE P-EFFICIENT PROBLEM IN LOCATION ANALYTICS: DEFINITIONS, FORMULATIONS, APPLICATIONS, AND FUTURE RESEARCH DIRECTIONS

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This paper aims to demonstrate the need for more extensive collaboration between two broad research areas: location analytics and performance analytics. We present a concise but comprehensive overview of the location analytics fundamental and its evolution, including a historical perspective, early challenges, seminal contributions, and a classification of the problems. The p-efficient problem in location analytics is introduced, where the primary objective is improving the overall efficiency of the network of facilities. We exemplify how performance analytics methods could be used in location analytics. Theoretical discussions are supported with real-world examples in healthcare. The perspective and techniques in this paper can enhance our ability to make location decisions more efficient and effective and give rise to new research questions and methodological approaches in both location and performance analytics.

M1-5 DEA METHODS I

Chair: Panagiotis Ravanos

ABSTRACT Nº: [213] - IDENTIFYING COST EFFICIENCY WHEN OUTPUT IS UNOBSERVED

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In this paper, we relax the standard assumption in productive efficiency analysis that all production factors are observed. We propose a nonparametric methodology for cost inefficiency measurement that accounts for the presence of unobserved output. In the spirit of DEA, we measure individual cost efficiency for the case that the output is either fully or partly unknown. Our advocated methodology is based on integer programming and we illustrate the usefulness of our approach by analyzing the inefficiency of countries.

ABSTRACT Nº: [17] - LAMBDA-RETURNS TO SCALE AND INDIVIDUAL MINIMUM EXTRAPOLATION PRINCIPLE

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This paper proposes to estimate the returns-to-scale of a production set by considering the individual returns-to-scale of each observed firm. Each individual returns-to-scale is estimated

through the goodness of fit approach proposed by Boussemart et al. (2019). The global technology is then constructed as the intersection of all the individual technologies. We propose an axiomatic foundation by introducing the notion of Λ-returns to scale that encompasses as a special case the standard definition of α-returns to scale (Boussemart et al., 2009). Along this line, it is shown that many production models involving variable, non-increasing and non-decreasing returns-to-scale appear to be special cases of models satisfying a Λ-returns to scale assumption.

ABSTRACT Nº: [82]- CORRECTED NORMALIZED ADDITIVE ANALYSIS – CNAA – AS COMPETITIVE METHOD FOR EASILY MEASURING RELATIVE EFFICIENCY

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In the last decades, various frontier-based benchmarking methods for measuring efficiency have been developed. As shown by several Monte Carlo simulations, these methods perform well in many scenarios. However, they are quite complex since optimization problems or stochastic problems have to be solved, for example for Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA). In cases where evaluators do not have profound knowledge about these subjects, an alternative approach could be of interest that is easy to use, handle and interpret.

In a previous simulation study, we found out that the simple and intuitive benchmarking method Normalized Additive Analysis (NAA) performs well regarding the correct estimation of the underlying ranking of decision-making units (DMUs). Most of the time, for NAA, the resulting mean Spearman rank correlations (MRCs) of the estimated and true rankings of DMUs are similar or even higher than for other methods like DEA or SFA. However, NAA underestimates the real efficiency scores systematically. In order to improve its performance in accurately estimating the efficiency scores and not only the ranking, we refined NAA similarly to the method of Corrected Ordinary Least Squares. Correspondingly, the efficiency scores are corrected so that at least one DMU reaches an efficiency score of 100%. We call this modification Corrected NAA (CNAA).

We use a Monte Carlo simulation to evaluate the performance of CNAA in comparison to the widely used deterministic DEA with constant and variable returns to scale. To this effect, we calculate the mean absolute deviation (MAD) between the true and estimated efficiency scores for numerous scenarios. In the respective scenarios, we vary parameters that reflect the underlying situation, for example, the number of DMUs, the level and distribution of efficiency, and the level of noise. Thus, we cover a wide range of possible scenarios.

In summary, our simulation shows that CNAA is able to strongly increase NAA's performance with regard to MADs while it keeps the high MRCs of NAA. There are many scenarios where CNAA even performs better than DEA, meaning that its MADs are lower than those for DEA. This is especially the case for rather low numbers of DMUs, not too much noise, and a gamma distribution of the inefficiency term. Apart from these scenarios where CNAA performs best, it is competitive in almost all other scenarios. In total, due to its simplicity and depending on the focus in a certain situation, CNAA can be an appropriate method for measuring relative

efficiency, especially in real-world benchmarking applications in which the user does not have much knowledge about efficiency measurement.

ABSTRACT Nº: [19] - ARE ALL MOST PREFERRED SOLUTIONS VALID IN VEA?

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In this paper, we explore the implications of using efficient Decision Making Units (DMUs) exhibiting different returns-to-scale as the Most Preferred Solution (MPS) in Value Efficiency Analysis (VEA) models. More specifically, we show that regardless of the returns-to-scale specification of the VEA model, the choice of an efficient DMU exhibiting constant-returns-to-scale as the MPS is valid, in the sense that it does not result in an efficient frontier violating production axioms. We also show that, in variable-returns-to-scale VEA models an MPS exhibiting increasing returns-to-scale is an invalid choice as the resulting frontier allows for infinite gains in productivity by scale expansion, while the choice of an MPS exhibiting decreasing returns-to-scale is invalid because the efficient frontier allows for free production of output. These results also hold when a combination of efficient DMUs is selected as the MPS, as long as this combination is expressed as an artificially constructed DMU that is included in the sample of existing DMUs.

M1-6 REGULATION I

Chair: Simone Di Leo

ABSTRACT Nº: [156] - COST EFFICIENT PROVISION OF ELECTRICITY DISTRIBUTION GRIDS: DOES OWNERSHIP MAKE A DIFFERENCE?

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The scientific discussion of whether state-owned or privately owned firms are more efficient in providing their goods and services has been held in great detail. The Agency Theory, the Property Rights Theory and the Public Choice Theory find different theoretical arguments why privately owned firms are superior to state-owned firms in competitive markets. However, this result does not necessarily hold for regulated markets. Until today, empirical studies are not conclusive on the role of ownership on firm´s performance. Hence, it is essential to understand whether state-owned firms perform differently and what determines this efficiency difference.

This paper aims to contribute to this discussion by analysing the effect of ownership on a cost-efficient provision of public infrastructure, on the example of electricity distribution grids in Germany. We estimate a sector-specific cost frontier using the four-component model. This approach disentangles firm-specific transient and persistent inefficiency from the firm´s heterogeneity and a random noise term. While transient inefficiency can be reduced in the short

term, persistent inefficiency displays the presence of a permanent structural deficit within the company. Applying the heteroscedastic four-component model allows us to determine the effect of the ownership structure on the persistent inefficiency term even further by modelling the mean and the variance of the persistent inefficiency as a function of the firm´s ownership structure. To describe firms´ ownership structure, we consider the ownership status (public vs state-owned), the number of owners of a firm, and the minority share of the firm which is privately owned.

Our empirical analysis builds upon a new and comprehensive panel data set of German distribution system operators from 2006 to 2016. This panel is constructed by merging several data sources. We use different micro data sets, which are provided by the Research Data Center of the Federal Statistical Office and Statistical Offices of the Länder. These data sets contain information on the firm´s investment behaviour and cost structure, the amount of electricity distributed and detailed information on the ownership structure of state-owned companies. Information on the physical characteristics of the distribution networks is provided by the data service provider ene´t.

ABSTRACT Nº: [98] - DISTRIBUTED GENERATION AND COST EFFICIENCY OF GERMAN ELECTRICITY DISTRIBUTION NETWORK OPERATORS

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In this paper, we use a comprehensive and unique data set of financial, technical and structural characteristics of German distribution network operators from 2011 to 2017 to estimate both the transient and persistent cost efficiency of German distribution network operators. In addition, we analyze the effect of an increasing capacity of distributed generation from renewable energy sources on the total costs of distribution network operators. Our results indicate an average cost reduction potential of approximately 12 percent in the short term and approximately 18 percent in the long term for German electricity distribution network operators. Furthermore, we find that distributed generation from renewable energy sources is a significant cost driver in the production process of network operators. Our study thus contributes to the ongoing debate on incentive regulation and efficiency benchmarking in electricity distribution industries and provides valuable insights for policymakers and regulators.

ABSTRACT Nº: [143] -DISTRIBUTED GENERATION AND DSO'S TRANSIENT EFFICIENCY ACCOUNTING FOR WEATHER CONDITIONS – AN EMPIRICAL ASSESSMENT FOR SWEDEN

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Electricity distribution operators (DSOs) are not only crucial for supplying customers with electricity but also play a fundamental role in facilitating the energy transition towards a greenhouse gas-neutral, decentralized energy system. Worldwide, increasing efforts have been made to reduce greenhouse gas emissions by expanding small-scale renewable energy

generation, including small hydro, biomass, biogas, solar power, wind power, and geothermal power (distributed generation). DSOs are commonly required to connect those decentralized energy sources to their distribution grids with technological and, hence, cost implications due to their uncertain nature. This paper investigates the impact of renewable energy feeders on DSOs' cost efficiency.

The cost efficiency of DSOs has been widely addressed in the literature. Few empirical studies consider distributed generation when estimating the efficiency of DSOs (e.g., Wasterberg, Zhou, Lundgren, 2021; Agrell and Brea-Solis, 2017). Empirical work clearly shows that a variety of external factors, i.e. factors outside managerial control, influence both cost structures and the efficiency of electricity distribution operations. External factors that recently obtain a lot of attention include indicators of weather to account for weather conditions heterogeneity (e.g. Anaya and Pollitt, 2017).

Our analysis provides new insights into the impact of renewable energy feeders on DSOs' cost efficiency while accounting simultaneously for weather conditions by applying geo-matched data of Swedish DSOs. The analysis is based on the recently developed four-components model (see Badunenko and Kumbhakar, 2017). The novelty of our approach is that we distinguish between transient and persistent inefficiency and that we simultaneously include various weather variables when analyzing the impact of renewable energy feeders on DSOs' cost efficiency. We further control in detail for the settlement structure of customers.

The data comes from various sources, i.e. the Swedish regulatory body, Sweden Statistics (SCB), and the Swedish Meteorological and Hydrological Institute (SMHI). The weather variables are matched geographically to the DSOs' operating areas. Our data sample comprises 123 DSOs operating across Sweden and observed over a time period of six years (2014-2019). The total number of observations is 736.

We specify an input-distance-function with three inputs (labor, capacity and length of mains), two outputs (number of customers, amount of electricity delivered). Additionally, we include population density and settlement structure measures to account for operating area differences. Further, we specify the variance of the transient inefficiency as a function of the number of small-scale feeders on both low-voltage and high-voltage levels, the average precipitation, average snowfall, average temperature, average cloud coverage and average wind speed. Preliminary results indicate that transient inefficiency decreases with small-scale feeders and average precipitation and snowfall while it decreases with average temperature, wind speed and cloud coverage. Overall, the mean efficiency of the DSOs is 92.47%. The insights have particular relevance for European regulators and policy makers for the discussion on facilitating the energy transition towards a greenhouse gas-neutral, decentralized energy system.

ABSTRACT Nº: [88] - ASSESSING AND EXPLAINING RECYCLE EFFICIENCY OF THE ITALIAN URBAN WASTE MANAGEMENT WITH APPROXIMATIONS OF NONPARAMETRIC FRONTIERS

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Due to increasing consumption and urbanization, urban waste management has gained a lot of attention in recent years. One of the main problems in this field is the balance between management costs, proper waste collection, and waste recycling capacity. Waste collection is critical to pursue a high recycling capacity. Two main types of collection can be identified: sorted waste, which results in a separate collection and after recycling or composting, and unsorted waste, which does not result in a separate collection. As a result, Italy´s main concerns in recent years have been urban waste management and recycling.

Italian urban waste management is organized around the ideal territorial area (so called ATO) defined in the regional plan, which influences the local waste system.

We analyze sorted waste costs, unsorted waste costs and additional costs and the tons of sorted and unsorted waste collected for 107 Italian provinces in 2015-2019. The data used for the study were collected from the Waste Register National Section of ISPRA.

We apply recently introduced parametric approximations of nonparametric frontier models (Daraio and Simar, 2022) to estimate meaningful coefficients of the different cost efficiencies, related to sorted and unsorted waste, without having to assume any hypothesis on the distribution of the inefficiency, and capturing the shape of the efficient frontier instead of the middle of the cloud of the observations. We extend the analysis by (i) including external and environmental conditioning factors, related to territorial, environmental, economic and sociological differences, to account for regulatory differences between and within regions; (ii) including the time dimension to consider the evolution over time of the estimated cost efficiencies.

M2-1 -AGRICULTURE II

Chair: Alfons Oude Lansink

ABSTRACT Nº: [41] - FARM-LEVEL WEFE NEXUS COMPOSITE INDICATOR: ASSESSING THE PERFORMANCE OF OLIVE AND GRAPEVINE PRODUCERS IN CRETE

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Among all the economic sectors, agricultural production is the one that heavily relies on the availability and quality of natural resources. Given the increasing scarcity of natural resources and the intensive resource nature of agricultural production, resource use efficiency at the farm level has received special attention. Since there are complex interconnections among the sectors of water, energy, food and ecosystems (WEFE), it is important to consider the nexus approach in such type of analysis. One way to explicitly place agricultural production within the WEFE Nexus is to develop a composite indicator that will reflect interlinkages between agricultural production and the water, energy and ecosystems pillars of the Nexus.

Our study contributes to the existing literature in two main directions: we propose a methodology to calculate the farm-level WEFE Nexus composite indicator based on farm accountancy data using mathematical programming. In addition, our composite indicator

incorporates the ecosystem component of the Nexus providing in-depth understanding of how environment and agricultural production interact.

The developed index has 4 pillars that account for links within the WEFE Nexus. In particular, the technical efficiency of the farm is the first component of the composite indicator. It reflects food-water and food-energy links via the incorporation of water and energy costs (in constant prices) as inputs of the production function, which is estimated using the nonparametric method (Data envelopment analysis). The remaining 3 components of the index, CO2 emissions from the application of nitrogen fertilizers, adoption of agri-environmental schemes (crop diversification) and subsidy value for organic farming, account for the link between food and environment. The WEFE Nexus index is an arithmetic mean of normalized values for each of the four components.

We use a dataset that covers olive and grapevine producers operating in 4 prefectures of the Crete island in Greece: Chania, Rethymno, Lasithi and Herakleion. It is an unbalanced panel with 198 observations in total covering the period from 2015 to 2017. Our preliminary results suggest that farms are characterized by a medium level of performance within the WEFE Nexus with a mean index value of 0.59 and with a coefficient of variation of 27%. With regards to the index components, the average value of farms' technical efficiency is 0.7, around three-fifths of farms adopt crop diversification while more than 80% are engaged in organic farming.

ABSTRACT Nº: [157] - PAYMENTS FOR ENVIRONMENTAL SERVICES AND COFFEE PRODUCTION: AN OUTPUT DISTANCE FUNCTION MODEL IN COLOMBIA

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Colombian coffee price describes volatility in the world market and land use change has increased pressure on natural resources, leading to unbalance of ecosystem. NGOs and local government launched payments for environmental services (PES) schemes, like an incentive to farmers protecting the ecosystem. Farmers face the making decision process about focusing their limited resources to produce more coffee or to ensure environmental services. To what extent does farmers describe efficiency within production of coffee and environmental services?

The output distance function considers the proportional expansion of outputs holding the inputs constant (Shepard, 1970). Literature focuses on 'good' and 'bad' outputs to analyze the trade-offs between agricultural production and environmental protection. However, mechanisms like PES schemes are suitable to be studied like two 'good' outputs. Trade-offs between environmental services and agricultural production have been studied in China, applying distance function methods (Li et al., 2020). The paper found that increasing agricultural production would be at the cost of decreased water yield and soil conservation. Villano et al. (2010) studied the synergies of two outputs in Australian farms, where found strong complementarity within the dual production. Our research provides further evidence on the efficiency in production of two outputs: environmental services and coffee production.

We collected 197 observations in-site by survey to coffee growers in the Colombian Andes about the cropping year of 2017.

Distance function D(x,y) reports the Shepard output oriented technical efficiency. The unit of observation is the farm I, Y1i is coffee revenue in dollars. Y2i is payments for environmental services. Xk represents the vector of inputs, which are X1 capital in dollars, X2 labor in terms of number of workers and X3 land with hectares of coffee. We included location variables like altitude, temperature and precipitation, land use, other input like dummy variables like the use of certified seeds, pesticides, ownership of equipment, the ability of farmers to produce specialty coffee, high quality attributes, and export-oriented production, the ability to face climate change and the presence of environmental conflicts, and other management attributes like age, education, living standard and continuity of sons in coffee production. We estimated the output-oriented mean adjusted Translog distance function, and we consider the properties suggested by Färe & Primont (1995) and Coelli et al. (2005).

The estimation of output oriented Translog distance function shows us that distance is significant between both outputs: coffee production and PES. Increasing PES leads to lower coffee revenue.

Results provide inputs for policy makers to improve mechanisms oriented to balance economic stability and environmental protection among coffee farmers. The research offers evidence about the efficiency of growers to manage both outputs: coffee and PES. Environmental protection policies could be strengthened with the main findings, leading to a new generation of PES schemes.

ABSTRACT Nº: [191] - FRONTIER ANALYSIS FOR PRACTICAL BENCHMARKING USE IN AGRICULTURE: WHAT ABOUT HETEROGENEITY?

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Frontier analysis is abundantly used not only for (in)efficiency scoring as such, and thus indicating productivity improvement potential, but also for peers' analysis, indicating potential reference points in pursuing improvement paths. More than in the case for the mere efficiency scoring exercise, the search for appropriate peers might suffer from heterogeneity in the population. This presentation starts from some practical, already published or ongoing, cases and aims at analyzing what heterogeneity, method choice, existence of outliers mean for deriving peers for adequate benchmarking. We start from the relatively homogeneous case of pig finishing focused on improvements paths. Then, heterogeneity with prior and posterior farm classification is treated on dairy farming cases in Flanders and Uganda. Finally, special attention will be paid to two cases with low data availability. The first one aims to find links between animal welfare and productivity and cost efficiency in dairy farming. Data are characterized by detailed and scientifically sound monitoring of animal welfare scores, but productivity estimates are rather rough. The second case is on European bee-keeping, characterized by an enormous variability ranging from professional to pure hobbyists, in which we want to find links between productivity and management style and environment. The presentation try to come to some meta lessons learnt on possibilities and pitfalls in searching for relevant benchmarks in heterogeneous populations.

ABSTRACT Nº: [94]- ENDOGENOUS DYNAMIC INEFFICIENCY AND OPTIMAL RESOURCE ALLOCATION

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The measurement of dynamic cost efficiency accounting for intertemporal changes in the amount of quasi-fixed factors such as capital, relies on the directional distance function to quantify technical inefficiency. Subsequently, resorting to duality theory, it identifies allocative inefficiency as the difference (residual) between cost and technical inefficiencies. However, the adoption of an exogenous directional vector in the conventional approach forces the reduction of inputs and the increase in investment, a situation that is at odds with reality when some firms find it optimal to increase some of their inputs or reduce investments so as to minimize long run costs.

The objective of this paper is to enhance the conventional approach to measuring dynamic inefficiency by endogenizing the dynamic directional function. The newly developed approach prevents non-monotonic and unrealistic managerial prescriptions on the intertemporal (dynamic) adjustment of inputs and investment. The model can be applied to any organizational form that uses quasi-fixed inputs, where the optimal allocation of resources is based on an intertemporal optimization model that requires the change in some flow variables representing the change in the stock.

We propose a model that endogenizes the directional distance function when solving for dynamic cost inefficiency. In contrast, the conventional model with exogenous directions results in a subjective decomposition of cost inefficiency which may lead to contradictory recommendations. The newly developed model provides managers with monotonic prescriptions. The model is empirically implemented using Data Envelopment Analysis (DEA).

We illustrate the endogenous model and its conventional counterpart using a dataset of EU firms in the dietetic food industry. The data were taken from AMADEUS and the final sample consisted of 143 firms over the period 2011-2017, divided into Eastern European firms (27 firms), Southern European firms (91 firms) and Western European firms (25 firms). The data include information on one output, two variable inputs (materials and labor) and one quasi-fixed input (capital).

On average, dynamic cost inefficiency in Europe amounts to 17.235 million dollars in 2014 and 11.575 million dollars in 2017. These values imply that the potential dynamic cost saving in the whole Europe is equal to 35.7% (=17.235/48.252´100) of total cost in 2014, and 21.3% (=11.575/54.327´100) in 2017. The potential cost saving is largest in Western Europe, and smallest in Eastern Europe. The differences in the managerial prescriptions between the conventional approach to measuring dynamic inefficiency and the new endogenious directional distance function approach are striking. The conventional model wrongly recommends reductions in inputs that are underused vis-a-vis their optimal long run cost minimizing amounts.

M2-2 - DEA APPLICATIONS I

Chair: Angelo Zago

ABSTRACT Nº: [74] - A FUZZY DATA ENVELOPMENT ANALYSIS APPROACH ON THE 'HEALTHCARE ACCESS AND QUALITY' INDEX

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Data uncertainty is an issue inherent to real-world applications that troubles researchers involved in quantitative research. In particular, when collecting input and output data regarding each decision-making unit (DMU) for conducting a Data Envelopment Analysis (DEA), data accuracy is crucial for its traditional use. For this reason, fuzzy DEA has been proposed in the literature to incorporate uncertainty into the evaluation. Therefore, when we are dealing with sectors and amounts of data in which information can only be collected via estimates, fuzzy DEA is called for. In this paper, we take a look at the prominent 'Healthcare Access and Quality' (HAQ) index to address its limitations regarding data uncertainty by proposing an enhanced methodology that overcomes some drawbacks of the HAQ index's one. Besides, we incorporate health financing determinants as inputs in order to improve upon the HAQ index. Note that the variables used to compute the HAQ index represent amenable mortality levels (and, thus, are undesirable indicators), which poses additional challenges when designing the fuzzy DEA model. To ensure a homogeneous comparison among all DMUs involved in the benchmarking exercise, we have clustered them before the assessment. Ultimately, we use fuzzy DEA to estimate the lower and upper technical efficiency scores of 195 countries and territories and compare them with the original HAQ index results.

ABSTRACT Nº: [150] -AN ANALYSIS OF THE INNOVATION INDUCED EFFECT OF EXPORTING: HOW EVIDENTIAL IS THE CAUSAL IMPACT WITH TECHNOLOGICAL AND NON-TECHNOLOGICAL APPROACHES

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This paper builds on the innovation theories to estimate the innovation-induced effect of exporting. Using an Extended Regression Model (ERM) – the Ordered Probit Estimation approach, it investigates the data obtained from the community innovation service (CIS) and accounting data for 2016 to 2018 from Norway's perspective. It further investigates how the firms' technological and non-technological innovation approaches are associated with the innovative performances of the exporting and non-exporting firms. The results can contribute to the literature while filling a gap in the ongoing debate with valuable suggestions for decision-makers.

ABSTRACT Nº: [139] - ESTIMATING PERFORMANCE AND SAVINGS OF WATER LEAKAGES AND UNPLANNED WATER SUPPLY INTERRUPTIONS IN DRINKING WATER PROVIDERS

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Access to drinking water is recognized by the United Nations as human right. Water providers (usually water utilities or water companies) are responsible for supplying drinking water to customers 24 hours per day since the continuous water supply involves significant social benefits. Moreover, from a quality of service perspective, unplanned water supply interruptions has been identified as one of the most relevant variable for customers´ satisfaction. Currently, 2.3 billion people live in water-stressed countries (UN-Water, 2021) and about 4 billion people experience severe water scarcity during at least one month of the year. Hence, within the urban water cycle, one of the main challenges that water providers face is to reduce water leakage. Due to the relevance of both quality of service variables (unplanned water supply interruptions and water leakage), the performance assessment of water providers should integrate them.

The integration of quality of service variables in the efficiency assessment of water companies is a researched topic in the literature. Several past studies introduced quality of service variables as undesirable outputs in the assessment of the efficiency of water companies. The limitation of the past studies is that the efficiency of water companies was derived by assuming a proportional reduction of all inputs for a given level of output. In other words, an aggregate efficiency score was calculated and thus, it was not possible to calculate an efficiency score for each quality of service variable used in the study. We fill in this gap in the literature by using a methodology that allows us to quantify the trends in variable-specific efficiencies. An approach that calculates a separate efficiency score for each variable of interest is the multi-directional Data Envelopment Analysis (MEA) technique, which was developed by Bogetoft and Hougaard (1999) and Asmild etal. (2003). This approach is appropriate for situations where the interest is on the measurement of the efficiency and potential improvements of particular variables.

Against this background, the objectives of this study are twofold. The first one is to estimate the efficiency of a sample of water companies focusing on water leakage and unplanned water supply interruptions metrics. In order to do this, for the first time, the MEA approach was employed. This approach also allows us to quantify the potential savings in water leakage and unplanned water supply interruptions, which is the second objective of this study. Our case study focuses on several water companies, public and private, that provide water services to customers in Chile over the years 2007-2018.

The main findings of our study can be summarized as follows. First, the Chilean water industry needs to substantially improve its water leakage and unplanned interruptions efficiency. In particular, it was found that during the years 2010-2018 the Chilean water companies could improve its efficiency in terms of water leakage and supply unplanned interruptions by 28.56% and 52.53% on average, respectively, to produce the same level of output. Secondly, large divergences among water companies are identified which reveals that policies adopted by the Chilean regulator have failed in achieving a homogeneous quality of service for all customers. Thirdly, on average, Chilean water companies could save around 48,166,000 m3 of drinking

water per year. This figure is not negligible in comparison to other measures evaluated by the Government to increase water supply. In terms of continuity of service, it has been estimated that from 2007 to 2018, Chilean water companies could reduce their unplanned water supply interruptions by 74.1% which is equivalent to 62,419 hours per year.

ABSTRACT Nº: [190] - COMPARING JUDICIAL EFFICIENCY ACROSS COUNTRIES. THE NORTH VS. THE SOUTH OF EUROPE

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For several years there has been a growing number of studies assessing efficiency of district courts within a country. However, efficiency is defined in relations to peers within the same country, e.g., Swedish courts are only compared with other Swedish ones. This means that country specific DEA studies can be viewed upon as a national championship – but does best in a country necessary means best in a wider context, e.g., European championship?

Our study expands previous research on efficiency of district courts by comparing four countries, Italy, Norway, Portugal and Sweden. This is an interesting comparison, since each country has its own peculiarities. Italy, with an average length of trials among the highest in the industrialized world, is considered an inefficient judicial system. In addition, it is a very heterogeneous country, and so is its judicial system. Portugal, similarly, has a judicial system comparable to the Italian one, although it shows somehow better performance on some indicators. Norway and Sweden, on the other hand, are considered to have quite an efficient justice system. Comparing the functioning of the judiciary in these four countries, each belonging to areas with different quality of institutions and degree of overall inefficiencies, i.e., Northern and Southern Europe, proves to be quite insightful.

In this paper, using a unique set of data based on similarity and relevance of inputs and outputs, we compare the efficiency of these four countries courts of justice for the period 2015-2020. In the paper we combine growth accounting methodologies with a meta-frontier exercise over the four justice systems and decompose total inefficiency in within country (managerial) and between country (system) inefficiency.

M2-3 - SFA APPLICATIONS II

Chair: Laura María García-Carrizosa

ABSTRACT Nº: [20] - ESTIMATION OF STAFF USE EFFICIENCY: EVIDENCE FROM THE HOSPITALITY INDUSTRY

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We analyze the extent to which hospitality firms overuse staff using a production function model which considers firm heterogeneity and accounts for environmental variables in staff use. We decompose overall staff use inefficiency into transient and persistent inefficiency. To do this, we employ a state-of-the-art stochastic frontier model, which is estimated using daily data on 94 Norwegian hospitality firms from 2010 to 2014. The environmental variables, especially the annual time trend, seasonality, and days of the week are found to exert heterogeneous effects on staffing. The mean transient, persistent, and overall efficiencies of the hospitality firms are 69%, 67%, and 46%, respectively. We find that seasonality (days of the week) decreases (increases) transient inefficiency by about 4%, suggesting significant room for improvement in hospitality staff use.

ABSTRACT Nº: [247] - Impact of an Energy Consumption Standard on Total Factor Productivity: Evidence from Indian manufacturing firms

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One of the measures to address climate change is a reduction in fossil fuel and energy consumption in energy-intensive industries. In 2012, India implemented a cap and trade in energy intensity regulation for certain industries known as the PAT (Perform-Achieve-Trade) scheme. Under the scheme the identified units were assigned energy intensity reduction targets and allowed trade in energy saving certificates. In this study, we analyze the impact of this energy saving program for the industrial sector on the total factor productivity of Indian firms that belong to the cement, fertilizer, and paper and pulp industries. For this purpose, we first estimate a production function using different econometric approaches for panel data in order to obtain information on the level of total factor productivity growth rate of the firms. We then use a difference-in-difference approach to identify the impact of the policy on total factor productivity. The sample considered in the empirical analysis is composed of 86 firms in the cement industry, 60 in the fertilizer industry, and 210 firms in the pulp and paper industry observed over the period 2005-2015.

ABSTRACT Nº: [97]- THE EFFECT OF HIGH-SKILLED LABOR, CAPITAL, AND R&D INVESTMENTS ON SWEDISH FIRM PERFORMANCE

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For an innovative economy like Sweden, the growth of productivity is one of the most vital indicators for firms. Hence, our study aims to examine the effects of improved technology, the availability of high-skilled labor and the investment in R&D on firm's productivity as measured by value added per employee among Swedish start-ups and incumbents, SMEs, and MNEs in both the manufacturing and services sectors. The analysis is based on eight waves of Sweden's Community Innovation Surveys from 2004-2018. The firm's productivity is modelled with the frontier of production function with a time variable stochastic efficiency terms. We find that the effects of labour and capital are positive in almost all the sub-samples, where the sum of the coefficients exceed one, suggesting increasing return to scale. R&Ds, on the other hand, exhibit mostly non-significant results, except for sub-samples of incumbent firms, Non-SMEs, and manufacturing firms. The findings thus raise a discussion of the impact of R&Ds on firm's productivity and its policy implications.

ABSTRACT Nº: [148] - GENDER DIFFERENCES IN THE DURATION OF OCCUPATIONAL INJURY LEAVE: A STOCHASTIC METAFRONTIER ANALYSIS

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The time it takes for an injured worker after an occupational accident to return to work is mainly determined by the severity of the injuries suffered and the subsequent medical recovery process. However, the duration of sick leave may also be extended as a result of the injured worker's opportunistic behavior in a situation of moral hazard. This paper analyzes the duration of sick leave after an accident at work using a stochastic frontier analysis, intended to estimate the inefficiency of the duration of sick leave, defined as the excess of days beyond the expected medical recovery time. In this context, it is commonly argued that there are differences in the propensity for opportunistic behavior between male and female workers, largely grounded on differences in their attendance motivation. The paper builds on this literature and formulates a stochastic frontier approach in which the duration of sick leave is regressed on multiple explanatory variables for the expected time of medical recovery. Moreover, inefficiency is explained by environmental variables related to worker and firm characteristics that would trigger the injured worker's opportunistic behavior. We use a dataset with the occupational accidents that cause sick leave and occurred in the service sector in Spain during 2015-2019. The stochastic metafrontier model estimates the inefficiencies in the duration of sick leave, as well as its decomposition into inefficiencies within each gender group, and a gender gap ratio, defined by the distance from the frontier of each gender group to the metafrontier. Preliminary results show that the duration of sick leave is significantly longer for women than for men and that the difference between genders increases with company size and public ownership.

M2-4 COUNTRY ANALYSIS I

Chair: Inmaculada C. Alvarez

ABSTRACT Nº: [207] - OPTIMAL SHARE OF TECHNICAL EDUCATION IN LABOR INPUT

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Given the structure of the economy, the labor market features a long-lasting mismatch between the supply and demand for technically educated labor as a production factor. Applying the idea of Luptacik and Bohm (2010) on constructing the economy´s own production frontier, we determine the optimal use of non-technically and technically educated labor across industries in the Slovak republic economy. For individual industries, best possible output as well as input use are determined. In the course of optimization, economic interdependencies are accounted for by the linear input-output model acting as a constraint along with the total primary factors endowment. The solutions subsequently enter a DEA model to generate the frontier of multi-output multi-input technology. The results could be relevant for educational policy design.

ABSTRACT Nº: [188] - INSTITUTIONAL QUALITY AND ECONOMIC DEVELOPMENT DETERMINANTS IN EUROPEAN REGIONS

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Since the seminal study by North (1990), the role of institutions in economic development remains a debate area. From a theoretical perspective, it is widely acknowledged that institutional quality is strongly linked to economic development (Rodrik et al., 2004). Despite the recent interest in analyzing the relation between the quality of local and regional government and regional performance, there is still relatively scarce evidence in European regions. Several articles have addressed this gap by examining the direct and indirect role played by institutional quality (Rodriguez-Pose and Ganau, 2022).

We contribute to this recent literature introducing a latent class model approach, to improve the knowledge about the existence of different patterns in investments in the traditional drivers of economic growth and in the direct and indirect effects of institutions in European regions. This model classifies the sample in groups according to the estimated probabilities of class membership (Orea et al., 2015). Another differentiating factor from previous studies is that institutional quality is considered as determinant of pertaining to one of those groups to identify its indirect effects through investment and European structural and investment funds.

The empirical application is performed on a sample of 237 EU regions during the period 2006-2018. The empirical is derived from an extended version of the Mankiw et al. (1992) model, incorporating innovation, transport infrastructures and European structural investment funds, and institutional quality parameters. Our preliminary results show that the quality of government is significant in classifying regions in the latent groups, and that its effect on the role of investment and European funds varies across regions.

PHD DISCUSSION SESSION 1

ABSTRACT Nº: [138] - OUTPUT-INPUT MIX AND FARM PERFORMANCE IN THE INDO GANGETIC PLAINS OF INDIA: A DIRECTIONAL DISTANCE FUNCTION ANALYSIS

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Discussant: Timo Sipilianen

Farmers in the Indo-Gangetic plains of India carry out resource-intensive farming. For instance, Punjab, India withdraws the highest amount of groundwater and uses the highest volume of fertilizer for agricultural cultivation. This has resulted in a severe decline in groundwater tables, groundwater pollution and higher cost of production. To ensure food security, provide livelihoods for people dependent on agriculture, and sustain food production, it is important to understand the degree of inefficiency and establish how much output expansion and input savings can be achieved.

Most smallholder farm-households produce multiple outputs. There is limited or no research on the implications for productivity and revenue efficiency of cereals and other output mix chosen by farmers. Previous studies examined production efficiency by aggregating multiple outputs as output revenue and used frontier or other models that do not capture the true nature of the production technology. These studies also ignored the impact of output mix choices on efficiency and revenue. This study addresses these shortcomings by using output-input directional distance functions (DDF) to estimate the technical efficiency of multiple output-producing farm-households. Besides standard inputs, our model incorporates variables that describe the production environment and agricultural technology, as well as demographic and other factors, affecting inefficiency levels. This study used data collected randomly from 356 farm-households from three districts of Punjab, India in 2015. Farm-households grow irrigated rice and/or cotton in the rainy season and wheat in winter.

DDF is estimated as a stochastic frontier using Bayesian techniques, imposing concavity and other regularity properties. Production inputs include land, labor days, irrigation hours, and other variable costs, while cotton, rice, and wheat output are the output variables. The study also estimated efficiency levels using deterministic frontiers (DEA and parametric) for comparison purposes. The results from the deterministic and stochastic models suggest that, on average, the effect of productive inefficiency is that output is below the maximum possible by an amount equivalent to between 10% and 19% of the sample mean input-output levels. Use of improved land preparation technology and improvements in soil quality were found to have upward or positive effects on productivity. Old farmers and farmers with off-farm income were found to be less efficient. Land ownership and canal irrigation, on the other hand, were found to have a positive effect on efficiency.

The results reveal considerable technical inefficiency in the production system. This result suggests that eliminating inefficiency can increase output and reduce input use simultaneously. To increase efficiency, land reform and surface irrigation need to be strengthened. Infrastructure should also be developed to make improved agricultural technology easy to adopt.

ABSTRACT Nº: [169] - THE ROLE OF PRINCIPALS´ MANAGERIAL PRACTICES: AN EMPIRICAL ANALYSIS OF SCHOOL EFFICIENCY AND EFFECTIVENESS

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Discussant: Cinzia Daraio

In this paper, we uncover the mechanisms through which school principals´ managerial practices affect school efficiency and effectiveness. To do so we develop a measure of variables importance which accounts to assess the impact of exogenous variables in the context of conditional efficiency estimation. Firstly, we evaluate schools´ performance through a conditional Data Envelopment Analysis. This approach allows accounting for the endogeneity of principal practice and for the heterogeneous school environment they might have to face. Secondly, we investigate how the managerial practices affect these performances and possible interactions effects between managerial practices. Data refers to a nationally representative sample of Italian schools in 2019 and students in the 8th grade. Findings support the understanding of the relationship between managerial practices and organizational efficiency in the public sector.

ABSTRACT Nº: [173] - SHORTAGE FUNCTION AND MULTI-FACTOR PORTFOLIO SELECTION: A DUAL APPROACH

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Discussant: Jaap Bos

This paper proposes a nonparametric efficiency measurement approach for the static portfolio selection problem in mean-multi-factor variance space. A shortage function is defined that looks for possible increases in return and decreases in a multi-factor variance space. Global optimality is guaranteed for the resulting optimal portfolios. We also establish a link to a proper indirect mean-multi-factor utility functions. This framework permits to differentiate between portfolio efficiency and allocative efficiency components. Furthermore, in principle, information can be retrieved about the revealed factor risk aversion of investors.

M3-1 - AGRICULTURE III

Chair: Mette Asmild

ABSTRACT Nº: [70] - DECOMPOSING REVENUE EFFICIENCY: AN APPLICATION TO FISHERIES

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In recent years, the reduced profitability of the fishing activity is receiving increasing attention. Low fishermen income leads to a decrease in the number of fishers and to a reduction in the income of fishing villages.

A solution to the problem of low fisheries income may come from an increase in the productive efficiency of the fishing boats. The study of technical efficiency has relied on the estimation of production frontiers, defined as the maximum amount of output achievable from a given set of productive inputs. The difference between this theoretical maximum and actual data is considered as technical inefficiency. The estimation of production functions using revenue as the dependent variable is very common in fisheries research since in multi-species fisheries boats catch several species and their output must be aggregated somehow. This is the approach followed by many researchers in fisheries.

The objective of this paper is to explore the impact on this measure of technical efficiency of boat-specific prices and the species-mix of the catch. It is expected that higher boat-specific prices and a higher proportion of high value species in the catch, increases this measure of technical efficiency.

For that purpose, we first estimate a production frontier using as output the value of catch using average species prices instead of boat revenue. This frontier provides a measure of technical efficiency free of the effects of boat specific prices of species. In other words, a “pure” measure of technical efficiency. Second, we propose a decomposition of technical efficiency computed with boat revenue that quantifies the role played by boat prices and the species-mix of the catch.

In this study, we use a stochastic production frontier model to estimate the efficiency of the boats. For this study, we have assembled an unbalanced panel dataset of fishing vessels observed from 2003 to 2018. The dataset contains detailed information on fish prices received by each boat for each species. Such level of granularity enables the decomposition of technical efficiency proposed in this paper.

ABSTRACT Nº: [230] - ENVIRONMENTAL EFFICIENCY OF GERMAN TROUT FARMS IN NORTH-WEST GERMANY

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In recent decades, worldwide aquaculture production has grown massively. However, in the EU, the growth rates were marginal and in some subsectors negative despite more than 3bn euro of funding and sector development strategies. EU water quality improvement goals were seen as incompatible with aquaculture production conservation or enhancement. Previous literature in marine settings showed a close correlation between production and environmental performances. Despite also major production in freshwater aquaculture, there is only scarce information if the same relations can be found.

Therefore, we analyse the Trout production in Germany. Germany is the biggest market for trout and has favourable production and demand characteristics. However, production and self-sufficiency decreased strongly in recent decades. Our representative sample of 32 farms depicts the heterogeneity of farms adapted to the specific local conditions. At the farm level, information on the environmental performance was limited. Therefore, the Danish ´´Dambrugsmodel´´ was used to estimate each farm´s nutrient emissions and compare different scenarios of future developments. Then we used the estimated emissions as undesirable outputs in non-parametric efficiency analysis. Here different established methods to model the undesirable outputs like DDF, SBM and transformations are used to compare the environmental performance under different approaches.

The results show that the range of estimated environmental efficiency scores is smaller than operational efficiencies without accounting for the undesirable outputs. The efficiency scores are further uncorrelated with the resilience of the production against extreme environmental conditions in 2018 and the future expectations of the farms.

ABSTRACT Nº: [8] - TRANSIENT AND PERSISTENT EFFICIENCY OF EUROPEAN PIG FARMING: A FOUR COMPONENT PANEL STOCHASTIC FRONTIER APPROACH

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Pig farming plays an important role in the European agricultural economy. The relevance of this sector in Denmark, France, Spain and Poland as a leading EU pig producers makes the analysis especially interesting to assess the performance of pig farms in these countries. To do so, we estimate the persistent and transient efficiencies levels using a four components stochastic frontier model that allows accounting for the heterogeneity issues. The empirical analysis relies on a sample of farms specialized in the production of pig meat in four EU countries for the period 2010-2015. The results show that persistent efficiency is more relevant for Spanish, French and Danish farms, with average scores of 94%, 89% and 87% respectively. Transient efficiency is the most important component for Polish farms achieving an average level of 93%. On average, Danish Farms displays the highest total efficiency scores of 76% while Spanish producers present the lowest level of 72%. Our empirical findings could provide important policy decisions in the pig sector. Pig framing may need implementing new policies to improve the structure of the production system in Poland, while the rest of countries could focus on short-term incentives to improve transient efficiency of farms.

ABSTRACT Nº: [141] - DETERMINING DIFFERENCES IN PRODUCTION POSSIBILITIES

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In this paper, we examine differences in the production possibilities for two subgroups within a data set, here specifically two species of farmed shrimp in Indonesia. The comparison is not trivial since the scale of operations differs between the two groups, and furthermore the technologies are likely not characterized by constant returns to scale (CRS), neither across nor within the groups. Therefore, a sequence of tests, based on recently developed permutation methods, are applied: First, we test whether each frontier differs significantly from CRS. Based on that result, we can now correctly specify a test for whether the frontiers are significantly different. However, a hyperbolic efficiency measure is needed to avoid undefined between-group (or cross-frontier) efficiency scores in the absence of CRS. Yet, that in turn makes the inclusion of some relevant weight restrictions difficult, since a dual (multiplier) formulation of the programming program does not exist. This problem is overcome by transforming the weight restrictions in the multiplier space into corresponding tradeoffs in the envelopment space. We finally attempt to solve the corresponding non-linear programming problem and formulate additional tests comparing frontiers influenced by weight restrictions/production tradeoffs.

M3-2 - DEA APPLICATIONS II

Chair: Nicky Rogge

ABSTRACT Nº: [168] - AN MPSS-BASED METRIC FOR SCALE ELASTICITY IN DEA

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Fair pricing is central to competition policy, which brings into the forefront the nexus between profitability and the most productive scale size (MPSS). Hence calculating scale elasticity against MPSS gives a more intuitive economic meaning to our proposed metric. To this end, we introduce new models that provide a single measure of scale elasticity for both efficient units and the projection of inefficient units to the frontier. For efficient units we use the hyperplane closest to MPSS as the reference point to calculate scale elasticity. We project inefficient units to the variable-returns-to-scale frontier in the direction to the nearest MPSS hyperplane with minimum disruption to their existing production technologies. We illustrate our proposed approach using a real world data set of New Zealand electricity distributors. Our empirical application, where price settings are based on average productivity improvements, demonstrates the effectiveness of regulatory oversight on the most productive scale size.

ABSTRACT Nº: [46] – A SEMI-DYNAMIC NETWORK MODEL USING NON-RECIDIVISM AS FINAL OUTPUT

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Avoiding recidivism is the main goal with prison punishment and prisons provide several activities aiming at minimising recidivism, i.e., the tendency of a convicted criminal to reoffend. Many studies have reported findings of technical efficiency (resource use) for prisons around the world using outputs linked to activities within prisons. This study investigates efficiency of Swedish prisons using a semi-dynamic network model with non-recidivism as final output and activities performed within prisons as intermediate outputs. An important factor to handle when analysing prison efficiency is that there is heterogeneity regarding the severeness of crimes committed and therefore the need of attention within a prison. Sweden has prisons with three levels of security: low, medium, and high security prisons. A second novelty of this paper is that we adjust both inputs and outputs to improve comparability between different types of prisons. In the first part of the analysis, we keep our model close to previous research and model activities within prisons as outputs. Inefficiencies then range from 15 to 22 per cent using a VRS model. A result in line with other studies of technical efficiency for different Swedish public entities. In the second part of the analysis, we include non-recidivism as a final output and use the activities within the prison as intermediate outputs. When non-recidivism is modelled as the final output the average inefficiency is similar. However, the variation in efficiency is large and some prisons show large inefficiencies. Most excitingly is that we for some prisons can trace where efforts have been made to avoid recidivism. Our results show that technical inefficiency radically declines for these prisons when non-recidivism is included as a final output in our semi-dynamic network model.

ABSTRACT Nº: [107] - SUBSIDIES, EFFICIENCY AND PRODUCTIVITY OF ITALIAN THEATRICAL FIRMS. A SEMI-PARAMETRIC DB DEA APPROACH

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In the last few years, the economic consequences of the public debt crises have focussed new attention on the old question of whether there is an economic justification for spending tax revenue in support of the arts. However, despite its importance and the discussion on public subsidies there is not much empirical literature measuring the impact of public funds on the productive efficiency of firms operating in the theatre sector. The aim of this work is to fill this lacuna and to empirically evaluate both the efficiency and productivity of a set of 146 Italian cultural firms (opera houses, permanent theatres, and theatre production companies) over the period 2006-2014, and to examine the impact of subsides on their productive efficiency. To our knowledge this is the first study which examines the impact of subsidies on efficiency of Italian theatres at the individual (firm) level.

This paper builds on the previous efficiency studies for the performing arts institutions. However, in contrast to those studies which applied parametric stochastic frontier approach (SFA) to measuring efficiency, this paper applies a non-parametric Data Envelopment Analysis (DEA). This approach has not been applied in measuring the efficiency of theatres, also in contrast to other cultural institutions such as museums or libraries. The DEA offers useful and practical advantages over the SFA methods – in particular, it does not impose functional form restrictions on the underlying production technique of theatres. To control for the random error that is outside the producer's control, the robust double-bootstrap (DB) DEA is applied. This method allows not only to validate our non-parametric DEA scores but also to integrate the

effects of important determinants such as theatre subsidies in estimating the technical efficiencies, similarly to the SFA approach. Moreover, we also explore the total factor productivity change, including efficiency change over time, and obtain the total factor productivity (TFP) Malmquist index which is decomposed into technical efficiency change, scale efficiency change and technological change. The rich balance sheet dataset allows us to measure output as the deflated total operating revenues, while the labour input is measured as the number of employees, and the capital is measured as total assets, respectively. Efficiency determinants, including the subsidies at the firm level but also firm's characteristics and geographical location are included as important efficiency determinants in the second-stage DB DEA regression analysis.

The obtained robust DB DEA scores are close to the traditional DEA scores, and they are also very low indicating that Italian PA firms are on average very inefficient with an efficiency score of 24-27%. This finding implies that, by the given level of inputs, the total revenues of the Italian theatres could be increased by at least 76 to 73% in order to be fully efficient. Most importantly, our findings suggest that the impact of public funds on technical efficiency of the Italian theatrical firms is positive and statistically significant but the derived elasticity of public subsidy on inefficiency is smaller than one indicating that a 1% increase in subsidies will reduce inefficiencies by 0.11%. However, the obtained MPI index, and all three components of it, are all above unity for the Italian theatrical firms over the examined period, indicating that the TFP of Italian theatres increased over time which provides a counterargument that positive productivity change is not present in the theatre sector. Hence, we argue that investment in innovation, digitalisation, an increase in the quality and hence consumption in the theatre sector might have played an important role in increasing technical efficiency and productivity of theatrical firms.

ABSTRACT Nº: [12] - THE GENDER-EQUAL UNION? MEASURING FEMALE (DIS)ADVANTAGE AND ACHIEVEMENT IN EUROPEAN UNION MEMBER STATES USING A BENEFIT-OF-THE-DOUBT FRAMEWORK

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This paper examines gender (in)equality in the European Union and the EU countries across six core life domains, 'Work & Money', 'Knowledge', 'Power', 'Health', 'Safety, Security & Trust', and 'Life Satisfaction', for the period 2010-2018. The paper advocates a non-parametric frontier estimation approach for constructing and comparing opportunity sets for women and men across these six core life domains. The results reveal considerable differences across the core life domains with larger gender inequalities towards women being observed in the domains 'Power' and 'Work & Money'. However, overall, gender gaps seem to have decreased over the years. By 2018, results indicate a situation of (nearly) gender equality in four of the six core domains in the European Union. At the level of the Member States, results show a geographical pattern with northern countries being more gender-equal and attaining higher achievement scores across the domains, followed by western and then southern countries.

M3-3 - POLICY MAKING

Chair: Emili Tortosa-Ausina

ABSTRACT Nº: [27] - FIRM SUBSIDIES AND INPUT USE

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Subsidies for industry are a widely used policy tool. Policy makers hope that subsidies increase employment, improve competitiveness, and foster innovation. But despite these clear policy objectives, firms´ behavioural responses to subsidies are not well understood.

In this paper we focus on a single, theoretically founded, mechanism. How does subsidy affect firms´ input decisions? Relative input use has implications for economic efficiency and equity. Subsidies might cause relative input use to deviate from opportunity costs. Also, subsidies might affect the elasticity of substitution, which in turn affects the income distribution between capital and labor.

For our estimation we use an input distance function (IDF). This dual to the cost function facilitates the estimation of (absolute) shadow prices and only requires data on physical input and output quantities. Also, shadow prices (indirect demands) provide a natural measure for input substitutability, the Dual Morishima Elasticity of Substitution, i.e. shadow price changes in response to quantity changes.

ABSTRACT Nº: [42] - PUBLIC SUBSIDIES AND INNOVATION: A DOUBLY ROBUST MACHINE LEARNING APPROACH LEVERAGING DEEP NEURAL NETWORKS

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Economic growth is crucial in improving standards of living, prosperity and welfare. In order to generate sustainable growth, factors of production must continue to be accumulated without diminishing returns. While factors such as physical capital (machines and labor) exhibit diminishing returns to capital, knowledge and R&D offset these effects and make long-run growth possible. Nevertheless, market imperfections can drive R&D levels below the socially desired level and thus many governments intervene to in- crease the stock of knowledge, and knowledge spillovers via subsidies for research and development. Our paper uses European firm-level data to explore the effects of public subsidies on firms' R&D input and output. In order to deal with the complexity of the relationship between subsidies and innovation, non-parametric methods are used to learn functional relationships from the data. First, we estimate the average treatment effects based on the selection on observables assumption. Second, we consider the possible selection on unobservables, i.e., when unobserved characteristics of firms that affect in- novation drive the nonrandom subsidy assignment. In this case, we use instrumental variables (IVs) to identify the local instrumental variable (LIV) curve. The identification of the LIV is obtained via double machine learning that combines a double robust

IV estimation with neural networks and deep neural networks to learn functional forms from the data. We find that public subsidies increase both R&D intensity and R&D output with more pronounced effects on the R&D intensity of high technology and knowledge intensive firms. The effects of public support remain positive and significant even after accounting for treatment endogeneity.

ABSTRACT Nº: [302] USING STOCHASTIC FRONTIER ANALYSIS TO EVALUATE THE PERFORMANCE OF PUBLIC SERVICE PROVIDERS IN THE PRESENCE OF DEMAND UNCERTAINTY

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Public service providers generally make input decisions when the demand for their services is still unknown. To account for demand uncertainty, it is convenient to break the decision-making process into two distinct stages: a resource planning stage where managers choose inputs to meet expected demand, and a production stage where chosen inputs are used to meet realised demand. In our previous work, we developed separate measures of how well managers choose their inputs in the first stage and use their chosen inputs in the second stage. We then used data envelopment analysis (DEA) models to assess the performance of hospital and health service managers in Queensland (Australia). A problem with those models is that they made no allowance for measurement errors or other sources of statistical noise. In this paper, we overcome this problem using stochastic frontier analysis (SFA) models. We use Bayesian methodology to impose inequality constraints on the parameters of our models. We compare Bayesian predictions of variable cost and revenue efficiency with our earlier DEA results. We find that Bayesian predictions of variable cost efficiency exhibit much less variation than estimates obtained using the DEA approach; this is likely due to the fact that the DEA model does not allow for noise, so all deviations from the estimated frontier are attributed to inefficiency. Our Bayesian predictions of revenue efficiency are qualitatively similar to those obtained using the DEA approach.

ABSTRACT Nº: [26] - DOES POLITICAL ALIGNMENT MATTER FOR MULTI-LEVEL GOVERNANCE? AN APPLICATION TO THE CASE OF SPANISH DIPUTACIONES

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Modern states are organized in multi-level governance structures with economic and political authorities dispersed across them. However, although the consensus is relatively high when evaluating this form of organization versus a centralized authority, it is lower regarding the jurisdictional design, i.e., how to shed authority from central states to both supranational and subnational levels. This lack of consensus also exists in contexts with explicit initiatives to

strengthen their political ties such as the European Union (EU), and even within EU member countries.

The lack of consensus is aggravated with the relative scarcity of contributions that measure the advantages and disadvantages of different territorial organizations. We deal with these issues focusing on the case of a EU country, Spain, whose provincial councils (``diputaciones´´) are often under debate and controversy due to their contribution to increase public spending while simultaneously being (according to some) sources of inefficiencies, corruption and lack of transparency. Specifically, we evaluate how they impact on local governments´ performance combining a variety of activity analysis techniques, considering explicitly how the likely existence of political favoritism and political alignment might bias the results.

This relevant literature, however, has generally focused on the effect of political alignment on the quantity of transfers received, without taking into consideration how efficiently they are managed by local governments. We consider several scenarios might emerge, from local and regional bureaucrats cooperating closely and, therefore, contributing to a more efficient allocation of the public resources transferred to meet the local needs---in which case political alignment might be paying off---to other situations in which this lack of cooperation due to an absence of political alignment results in an opposite effect, i.e., inefficiencies with costly effects on local governments budgets.

We evaluate these issues proposing a two-stage model. The first one considers a newly developed Russell conditional model, which enables a separate evaluation for the efficiency of received transfers from upper levels of government, and the rest of the budget. In this process, we control for the impact of environmental variables that might impact on municipal finances. In the second stage, we consider a nonparametric regression to explicitly evaluate the impact of political alignment and political sign.

M3-4 – COUNTRY ANALYSIS II

Chair: Dimitrios Sotiros

ABSTRACT Nº: [37] - THE VALUE OF GREENHOUSE GAS EMISSION REDUCTION IN EUROPE

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The EU, as a political and economic community of 27 European countries, has become one of the most important global economic areas. In 2019, the EU was the third largest economy in the world, close behind the United States, with a 13.85% share of world gross domestic product. Coupled with the activities and growth of the EU and other economies, however, the environment is increasingly burdened by the simultaneous production of harmful greenhouse gases (GHG). For example, in 2019, the EU, including the UK, was among the top five emitters of GHG emissions. For this reason, in addition to economic growth, environmental protection issues and efforts to reduce GHG emissions are becoming increasingly important. In this context, the EU has evolved in recent decades from a merely economically oriented community to a global leader in climate change mitigation.

In addition to switching energy production from conventional to renewable energy sources, increasing energy efficiency is a key component of the EU´s climate protection strategy. Since CO2 emissions and other GHGs mainly arise in numerous production processes, identifying inefficiencies in the use of currently available production technologies probably yields a huge potential for reducing emissions. However, while productivity and efficiency issues play an important role in the economic literature, they are less discussed in environmental research and in the debate on reducing GHG emissions. Thereby, eliminating inefficiencies in the use of currently available technologies could provide decisive advantages, such as a reduction in emissions in the short to medium term or the avoidance of huge investments in new technologies.

Since the potentials for reducing GHG emissions in the EU related to inefficiencies are rather unexplored and unknown, the aim of our work is to provide a comprehensive analysis of these reduction potentials. We therefore address the question of to what extent the exploitation of these potentials can contribute to the achievement of the EU´s climate targets. Furthermore, we aim to provide insight into a cost-effective distribution of reduction targets by calculating the abatement costs of the identified reduction potentials. For our analysis, we consider a compiled data set linking production and emissions data for 16 EU member states (including the UK). In addition, to account for heterogeneous industrial structures of the member states, we estimate sector-specific reduction potentials and abatement costs for the most important industrial sectors. For our estimations, we rely on the non-parametric Data Envelopment Analysis (DEA) which allows to account for the joint production of good (desirable) outputs and bad (undesirable) outputs such as GHG emissions.

In this way, our research contributes to the literature in several ways: First, the methodological approach used provides a very good approximation of true inefficiencies and potential emission reductions based on historical production and emissions data. Moreover, we analyze several countries and sectors at the same time and thus obtain a detailed picture of the EU´s GHG emission and reduction activities. In this way, not only country-specific but also sector-specific reduction potentials can be derived. Furthermore, the calculation of abatement costs provide insight into the cost-effective distribution of reduction targets between countries and sectors. Overall, our work thus provides a comprehensive insight into the potential contribution of removing inefficiencies to achieving climate targets.

ABSTRACT Nº: [198] - AN INNOVATIVE BENEFIT-OF-THE-DOUBT APPROACH FOR HEALTH SYSTEM EFFECTIVENESS: A GLOBAL CASE STUDY ON AMENABLE MORTALITY

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Many different indicators can be used for health system effectiveness. Using composite indicators is a good way to summarize them all. One example of such efforts is the Healthcare Access and Quality Index from the Global Burden of Diseases study, for which different causes of mortality amenable to health care are summarized in this index through principal component analysis and exploratory factor analysis. While these approaches use the variance of the indicators, they do not consider room for improvement, i.e. distance to the frontier. In this study

we propose an innovative Benefit-of-the-Doubt approach as a solution for combining frontier analysis and composite indicators, using amenable mortality estimates for 188 countries.

ABSTRACT Nº: [101]- ANALYSING THE EXPORT POTENTIALS OF THE PORTUGUESE FOOTWEAR INDUSTRY BY DATA ENVELOPMENT ANALYSIS

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Exports are widely believed to play a central role in economic development and firms´ profitability, particularly in countries with small domestic markets. With that aim, governments and firms spend considerable resources on international promotion. Identifying the markets with the greatest potential for export growth is therefore crucial for an efficient allocation of public and private resources. In this paper, we propose a Data Envelopment Analysis framework to identify trading potentials with existing trading partner countries within an industry. To illustrate its applicability, we use data from the Portuguese footwear industry. Specifically, among the countries that currently import Portuguese footwear, we aim to identify those that have the greatest potential for increasing their imports from Portuguese footwear in terms of revenue. We further decompose this potential into price and quantity changes to provide strategic directions to the Portuguese footwear industry. For the analysis, we use panel data of 64 countries analyzed over the years 2011-2018. The results reveal that higher potentials lie among the countries of the European Economic Area. Overall, these potentials may be achieved through different price-quantity strategies.

PHD SESSION 2

ABSTRACT Nº: [122] - ASSESSMENT OF TECHNICAL EFFICIENCY AND PEER ANALYSIS FOR IMPROVED BENCHMARKING TO BOOST PRODUCTIVITY AMONG DAIRY FARMERS IN UGANDA: DEA VERSUS FDH

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Discussant: Alfons Oude Lansink

Food insecurity is still prevalent in sub-Sahara African (SSA) countries and this is likely to worsen by 2050 when over 25% of the world population will be living in Africa. Increasing food production thus becomes inevitable in such countries, but may worsen the pressure on the natural resources. SSA farmers are hence faced with a challenge of how to increase food output without putting additional pressures on the natural environment. To address this, improved effectiveness of extension programs and good insights of heterogeneities in efficiency analysis are very vital. As such, this study aims to 1) determine technical efficiency levels of dairy farms both on the meta-frontier and within their group specific frontiers so as to demonstrate the improvement potentials of these dairy farms and ii) to identify appropriate peers which can guide the inefficient farms to follow their improvement paths in an effort to increase production efficiency. To achieve these objectives, data was collected from 471 dairy farmers that belong to three different production systems in Uganda. The analysis is done using two non-parametric meta-frontier approaches (Full Disposable Hull and Data Envelopment Analysis) because of their ability to generate peers that can be used in benchmarking to enhancing effectiveness of peer- learning based extension approaches. Three inputs i.e. land, capital and labour; and one output (Amount of milk produced per month) are used in an output-oriented model. The results reveal that not all efficient farms can qualify to be used as examples to other inefficient farms in an effort to increase farm efficiency through peer-based learning extension approaches. More so, not all peers have similar effectiveness.

ABSTRACT Nº: [104]- STOCHASTIC FRONTIER ANALYSIS (SFA) WITH MEASUREMENT ERROR IN THE INPUTS

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Discussant: Luis Orea

To estimate production or cost functions and technical efficiency (TE) of firms in the framework of stochastic frontier analysis (SFA), certain conditions must be met. One of the conditions is that errors in the measurement of the inputs, caused by the collection of proxy data, for example, should be negligible. This work develops an SFA framework that corrects for proxies to construct the correct likelihood function when this condition is violated, but all others are met. We apply a pseudo maximum likelihood approach to treat the auxiliary nuisance parameters in the model, and Monte-Carlo integration scheme to solve the non-analytically solvable integral. The SFA model is based on that of Battese and Coelli (1992), with a translog production function and time series (panel data) input. Finally, we present a simulation study to compare the corrected estimates to the uncorrected estimates. Results show that correcting for measurement error has an essential effect on the estimation results, both of the production function coefficients and the TE scores.

THE IMPACT OF GOVERNANCE ON TECHNICAL EFFICIENCY OF CONTAINER PORTS

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Discussant: Chris Parmeter

This paper analyses the impact of governance related factors such as ownership, competition and economic regulation on the technical efficiency of an unbalanced panel of container ports in the Far East and Asian region by applying stochastic frontier analysis. The results show that smaller ports have a higher share of private participation but higher the percentage of private operators, higher the technical efficiency. Ports with low and moderate hinterland competition handle a significantly higher amount of containers in comparison to ports with high hinterland competition but ports with high hinterland competition have a significantly higher technical efficiency in comparison to ports with low and moderate hinterland competition. Ports facing transhipment competition have a significantly higher technical efficiency in comparison to ports which face no transshipment competition. Ports which are regulated by a government ministry, port authority and an independent regulator are significantly smaller than those that have market based pricing. Ports regulated by a government ministry have a significantly lower technical efficiency in comparison to those that have market based pricing. Ports regulated by the port authority or an independent regulator have a significantly higher technical efficiency in comparison to those that have market based pricing. Regulation by an independent regulator leads to a significantly higher technical efficiency in comparison to regulation by the port authority. Ports which are majority private, face high hinterland competition and have market based pricing have a significantly higher technical efficiency in comparison to combinations of most of the other ownership, hinterland competition and regulation variables. Nevertheless, ports which are majority private, face low hinterland competition and have market based pricing have a significantly higher technical efficiency in comparison to ports which are majority private, face high hinterland competition and have market based pricing. Moreover, ports which are majority private, face low hinterland competition and have an independent regulator have a significantly higher technical efficiency in comparison to ports which are majority private, face high hinterland competition and have market based pricing. Finally, when ports are majority private and have low hinterland competition, regulation by an independent regulator leads to a significantly higher technical efficiency in comparison to market based pricing.

T1- 1 AGRICULTURE IV

Chair: Kristiaan Kerstens

ABSTRACT Nº: [111] - ESTIMATION OF LOCATIONALLY HETEROGENEOUS PRODUCTION TECHNOLOGY AND PRODUCTIVITY: A STUDY OF NORWEGIAN DAIRY FARMING

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It is very common to assume homogeneity among observations in statistical/ econometric models. However, the agricultural sector includes activities that are driven by distinctive climate and geographical conditions, and the activities could also be affected by certain features of agricultural activities at the neighboring sites. These aspects call for spatial analysis of agricultural production to identify the spatial heterogeneity among farms (Postiglione et al., 2022).

Spatial heterogeneity can be accommodated in several ways. One is to use the spatially autoregressive (SAR) model in which a farm's output is affected by its neighbors' outputs and inputs (e.g., Glass et al., 2016). While accounting for the spatial/local use of output/input quantities, this approach still keep the production technology the same for all farms. A more flexible production function approach is to allow the local relationships to vary across space by considering how they behave nearby, as can be done with a geographically weighted semiparametric regressions (GWR) approach (Brunsdon et al., 1996).

In this paper, we use the approach of Malikov et al. (2021), while extending the two above mentioned spatial approaches in several ways. We estimate a location-specific production function, by using a semiparametric proxy-variable regression estimator. The parameters are nonparametric functions of farm's geographical location (latitude and longitude), and are estimated via kernel methods. The productivity components of this model also allow for determinants of productivity. With this method we, as opposed to the SAP-type production function which assume a common technology for all locations, estimate location-specific technologies, in addition to location-specific productivity estimates. Compared to the GWR approach, our method accommodates endogenous regressors (via proxy variable identification technique).

We apply our model to study locationally heterogeneous production technology and productivity among Norwegian dairy farmers, using a farm-level panel data covering the period 2004 to 2020. We test statistically to what extend technology and productivity vary across regions of Norway. The results will be presented at the workshop.

ABSTRACT Nº: [199] - EVALUATING THE IMPACT OF IMPROVEMENT PLAN SUBSIDIES IN SPANISH DAIRY FARMS

Authors: José Antonio Pérez Méndez[1]; David Roibás[1]; Alan Wall[1]

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The aim of this work is to evaluate the effects of Improvement Plans carried out by the government of the Spanish region of Asturias on the productive efficiency of dairy farms in the region. Improvement plans are subsidies for capital investment whose aim is to help modernize dairy farms by improving productivity and the quality of the product, thereby contributing to guaranteeing the economics sustainability of the farms.

To carry out our study, we construct a panel data set of dairy farmers over the period 2000-2014 with information from the regional Ministry for Rural Development and Natural Resources. Data on the Improvement Plans include the year an investment was made, the type of investment (including buildings, installations and machinery), the amount of the investment and the percentage subsidised. This is crossed with economic data on the dairy farms for the same

period 2000-2014 gathered through a public agricultural extension programme, where information is available on production variables, inputs, costs and revenues.

We use a stochastic frontier approach to investigate the extent to which the new capital is more productive than existing capital. In particular, we estimate a stochastic production frontier where the capital stock is disaggregated into pre-existing capital and the new capital installed under the Improvement Plans. This is then used to calculate productivity indexes which are used to evaluate the impact of the new investments on productive efficiency.

ABSTRACT Nº: [103] - BEEF CATTLE PRODUCTION OR DAIRY PRODUCTION, WHICH IS MORE ENVIRONMENTAL FRIENDLY? A STOCHASTIC META-FRONTIER ANALYSIS IN SWEDEN

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Diary production and beef cattle production operates around 80% agricultural production in Sweden, and they come as the first majority of greenhouse gas emission generator in Swedish agriculture. Using the farm accountancy data network (FADN) of specialist dairy farms and specialist cattle farms from 2004 to 2019 in Sweden and a stochastic meta- frontier production function, this study investigates the impact of Common Agricultural Policy (CAP) subsidies on the technical efficiency and the difference of input efficiency in terms of inputting chemical input (fertilizer and pesticide). The average technical efficiency is estimated as 0.83, with 0.86 for diary production and 0.79 for cattle production. Results reveal that agri-environmental payments have a statistically significant and strongly positive correlated relationship with farm technical efficiency in both of the two farm types, particular for diary production, and dairy farms are more environmental friendly in terms of using chemical input.

ABSTRACT Nº: [224]- ENERGY PRODUCTIVITY AND GREENHOUSE GAS EMISSION INTENSITY IN DUTCH DAIRY FARMS: A HICKS-MOORSTEEN BY-PRODUCTION APPROACH UNDER CONVEXITY AND NONCONVEXITY AND EQUIVALENCE RESULTS

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The agricultural sector is currently confronted with the challenge to reduce greenhouse gas (GHG) emissions, whilst maintaining or increasing production. Energy-saving technologies are often proposed as a partial solution, but the evidence on their ability to reduce GHG emissions remains mixed. Production economics provides methodological tools to analyse the nexus of agricultural production, energy use and GHG emissions. Convexity is predominantly maintained in agricultural production economics, despite various theoretical and empirical reasons to question it. Employing nonconvex and convex frontier frameworks, this contribution evaluates energy productivity change (the ratio of aggregate output change to energy use change) and GHG emission intensity change (the ratio of GHG emission change to polluting input change)

using Hicks-Moorsteen productivity formulations. We consider GHG emissions as by-products of the production process by means of multi-equation modelling. Given our empirical specification, nonconvex and convex Hicks-Moorsteen indices can coincide under certain circumstances, which leads to a series of theoretical equivalence results. The empirical application focuses on 1,510 observations of Dutch dairy farms for the period of 2010-2019. The results show a positive association between energy productivity change and GHG emission intensity change, which calls into question the potential of on-farm, energy-efficiency-increasing measures to reduce GHG emission intensity.

T1- 2 HEALTH I

Chair: Diogo Cunha Ferreira

ABSTRACT Nº: [7] - A DEA COMPOSITE INDICATOR OF GOOD GOVERNANCE AND ITS EFFECTS ON SUBJECTIVE WELL-BEING

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The aim of this research is to explore the relationship between good local governance and subjective well-being. Good governance relates to effective and incorrupt government. We define three dimensions of good governance at the municipal level: accountability, government efficiency and control of corruption. Government efficiency is measured as a composite indicator of a series of variables related to sound financial management of the local government. We use a DEA approach with weight restrictions in order to obtain this composite indicator. We then use a large survey carried out in Spain in 2013 and 2018 in order to examine the effects of good governance on individual well-being. Our results show a U-shaped effect of ageing on SWB and a very strong positive effect of cohabitation. Gender and nationality seem to play a much smaller or even insignificant role. Social connections or health status emerge as major drivers of subjective well-being. With respect to good governance, our results point to an immediate positive effect of government efficiency on individual well-being. Accountability, understood as transparency, does not seem to have a significant impact. Surprisingly, we find no immediate effect of corruption either. However, we find a very strong deferred effect of controlling corruption on future reported well-being. Therefore, corruption seems to bring a delayed reduction in the population's satisfaction with life.

ABSTRACT Nº: [200] - SPANISH HOSPITAL PRODUCTIVITY: AN ILLUSTRATIVE STUDY IN THE TRAUMA SERVICE

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The objective is to evaluate the productivity of Spanish public hospitals in specific hospital healthcare service. The empirical analyses performed for this study are based on a set of time-

series indicators of the Spanish hospital sector. The data are derived from the Database Public Sector that contains information on hospital resources and activities in Spain.

The data consisted of 244 public hospitals in Spain during the period 2010–2018. Using the non-parametric framework, this study measured productivity growth over time with the Malmquist index including quality attributes, to evaluate the performance of the procedures realized in the trauma service. The inputs were beds and health professionals and the outputs were measured through outpatient visits and stays. Quality concerns are critical to hospital services. In this study, it was assessed by the number of inpatient mortalities in the trauma service. This paper adopts the one-stage approach, which includes quality attributes as freely disposable outputs into the production function on the assumption that producing quality binds additional input resources, and thus, has negative effect on production.

The empirical results showed that the productivity increases with time, the operational efficiency yearly improved. Causes for differences in efficiency and technology were related to the size of hospitals - higher in hospitals with more than 1,000 beds.

Regarding the quality, we have not yet evaluate the quality change between periods. The only results obtained indicate that hospitals with higher mortality in the trauma service obtained higher performance which means that hospitals seem to make tradeoffs between quantity and quality of care under constrained resources.

ABSTRACT Nº: [85] - EVALUATING THE EVOLUTION OF PORTUGUESE PUBLIC HOSPITALS PERFORMANCE AND SUSTAINABILITY BEFORE AND DURING THE COVID-19 PANDEMIC

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COVID-19 is a disease caused by the virus SARS-CoV-2, spread across the world since the beginning of 2020. By the time this work has been carried out (2022), the pandemic was not considered extinct yet. Several pharmaceutical and non-pharmaceutical strategies have been proposed, including vaccination and lockdowns, to contain the virus dissemination. One of the consequences of the pandemic was the denial or delay of access to proper health care services, but also the increase of adverse events within those services, like the number of nosocomial infections because of non-sterile clinical material (e.g., ventilators). Therefore, the main question here is: what did happen to the performance and sustainability of hospitals?

The main goal of this work is to test if the Portuguese public hospitals´ performance has been affected by the SARS-CoV-2 pandemic. Our methodological approach is based on the so-called Benefit-of-Doubt (BoD) method, a linear programming model that uses performance indicators instead of inputs and outputs (as in Data Envelopment Analysis). We include additional constraints over multipliers in BoD and integrate the model with the Malmquist Index to analyze the performance evolution over time. The Malmquist Index can be decomposed into several other indices that reflect the static and dynamic performance evolution of hospitals. Then, we can use a multiple regression model (with the stepwise forward heuristic) to test whether these indices can be somehow explained by some pandemic-related variables.

In our empirical case, we considered a database composed of 28 public hospitals located in Portugal mainland and evaluated from January 2018 to December 2021. The period 2018 to 2019 corresponds to the baseline (pre-pandemic), against which the remaining period will be compared (during the pandemic). We also considered fourteen variables characterizing hospital quality, which were divided into three main performance definitions (efficiency and productivity; access; safety and care appropriateness). As potential explanatory variables, we take into account seven dimensions, including vaccination rate and need for intensive care by COVID-19 infected people.

T1- 3 SFA METHODS I

Chair: Juan José Price

ABSTRACT Nº: [34] - ESTIMATION OF A VARYING-COEFFICIENT, FIXED-EFFECTS COBB-DOUGLAS PRODUCTION FUNCTION IN LEVELS

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We propose a semiparametric varying coefficient estimator for a Cobb-Douglas production function for panel data with several practical features. First, we estimate the model without a log transformation to avoid induced non-negligible estimation bias. Second, we disentangle the impact of traditional inputs from that of environment variables, which impact output indirectly through altering the output elasticity of inputs and the state of technology via unknown functions. We introduce a linear index structure in the unknown functions to circumvent the curse of dimensionality, and allow the output elasticity of different inputs to depend on different environment variables. Third, our technology function accounts for latent heterogeneity across individual units, which can be freely correlated with inputs and/or environment variables. Our estimator combines series and kernel methods for both the unknown parameters and functions. We demonstrate that the proposed estimator exhibits promising finite-sample performance.

ABSTRACT Nº: [96] - THE NOISE COMPONENT IN STOCHASTIC FRONTIER MODELS

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With a little help from a handful of scholars, the noise error component created the stochastic frontier analysis field. After that glorious moment, it was confined to obscurity and was showered with negligence, even though most of the times it represents non-modeled influencing factors rather than inconsequential ´´noise´´. We review what little research has been done on it. We provide mathematical formulas to predict it for the benchmark stochastic frontier model specifications, and examine the relations between predicted noise and predicted

inefficiency (some counter-intuitive results arise). We examine the ranking of observations according to the predicted noise component, compared to rankings obtained based on inefficiency.

ABSTRACT Nº: [54] - IMPROVING PREDICTIONS OF TECHNICAL INEFFICIENCY

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The traditional predictor of technical inefficiency proposed by Jondrow et al. (1982) is a conditional expectation. We study whether, and by how much, the predictor can be improved by using auxiliary information in the conditioning set. To do so, we use simulations to study two types of stochastic frontier models. The first type is a panel data model where composed errors from past and future time periods contain information about contemporaneous technical inefficiency. The second type is when the stochastic frontier model is augmented by input ratio equations in which allocative inefficiency is correlated with technical inefficiency. We consider a standard kernel-smoothing estimator and a newer estimator based on local linear random forest which helps mitigate the curse of dimensionality when the conditioning set is large. We also provide an illustrative empirical example.

ABSTRACT Nº: [242] - A ray-based input distance function to model zero-valued output quantities: derivation and an empirical application

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We derive and test an input-oriented distance function based on the stochastic ray production function suggested by Lothgren (1997, 2000). We show that the derived ray-based input distance function is suitable for modelling production technologies based on logarithmic functional forms (e.g., Cobb- Douglas and Translog) when control over inputs is greater than over outputs and when some productive entities do not produce the entire set of outputs, two situations that are jointly present in various economic sectors. We also address a critic the stochastic ray function has been subject to, namely its sensitiveness to the outputs' ordering. We estimate a ray-based Translog input distance function with a data set of Danish museums. These museums have more control over their inputs than over their outputs and many of them do not produce the entire set of outputs that are considered in our analysis. Given the importance of monotonicity conditions in efficiency analysis, we demonstrate how to impose monotonicity on ray-based input distance functions. As part of the empirical analysis, we estimate technical efficiencies, distance elasticities of the inputs and outputs, scale elasticities, and how the production frontier is affected by some environmental variables that are of interest to the museum sector.

T1- 4 MULTI-METHODS II

Chair: Giannis Karagiannis

ABSTRACT Nº: [38] - DATA ENVELOPMENT ANALYSIS WITH MARKOV MODELS, CURRENT DEVELOPMENTS AND RESEARCH DIRECTIONS

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This presentation begins with current developments on a modelling framework which combines Data Envelopment Analysis and Markov Chains into an integrated decision aid. The Markov Chain describes a population system at the start of its evolution and the aim is to transform the system to a desirable state by the end of a planning horizon. Initial state, recruitment policies and transition matrices may be influenced by the organisation and external factors. The baseline model (radial and additive variants) uses as a vehicle the homogeneous markov manpower planning system and the DEA model identifies feasible courses of action through convexity capturing the DM's relative preferences over future states of nature. The information produced provides a tool of interventions that would improve the chances of attaining the ultimate goal structure for the system. A numerical illustration supports the applicability of the model. In the second part of the presentation, we expand the above research and investigate alternative modelling approaches regarding variants on the DMUs or on the time horizon including multiple transitions of the system to successive states. The latter has connections akin to network DEA models. The paper concludes with a discussion about the advantages and limitations of this research avenue.

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ABSTRACT Nº: [241] - The role of Infrastructure, firms' efficiency and their survival: evidence from a combined productivity-duration approach

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Being able to forecast firms' decline is paramount in economics. In this paper, we investigate the main factors that lead companies to failure. By tracking a sample of agri-food firms in Italy, we compare different and very innovative inefficiency indicators with the most important and established financial variables in the literature. The inefficiency measures proposed account for the level of an infrastructural endowment at a territorial level. Through a semi-parametric approach, this paper demonstrates that infrastructures influence the productivity of firms, which in turn is the main determinant of firms survival. This has strong policy and managerial implications.

ABSTRACT Nº: [246] -A System Approach to Identification of Production Functions with Multi-Dimensional Productivity

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There is growing empirical evidence that firm heterogeneity is technologically non-neutral. This paper extends Gandhi et al.'s (2020) proxy variable framework for structurally identifying production functions to a more general case when latent firm productivity is multi-dimensional, with both factor-neutral and (biased) factor-augmenting components. Unlike alternative methodologies, our model can be identified under weaker data requirements, notably, without relying on the typically unavailable cross-sectional variation in input prices for instrumentation. When markets are perfectly competitive, we achieve point identification by leveraging the information contained in static optimality conditions, effectively adopting a system-of-equations approach. We also show how one can partially identify the non-neutral production technology in the traditional proxy variable framework when firms have market power.

ABSTRACT Nº: [16] - AN ALTERNATIVE REGRESSION MODEL FOR ESTIMATION AND INFERENCE IN OLLEY-PAKES PRODUCTIVITY DECOMPOSITION

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We propose an alternative linear regression model for providing inference and hypotheses testing in the Olley-Pakes productivity decomposition. In this model, firm-level productivity is regressed into a constant and firm's market share, instead of firm's demeaned market share scaled by the product of the number of firms and its cross-sectional variance. We show how the estimated parameters of this linear regression model can be used to provide estimates of and inference to the components of the Olley-Pakes decomposition as well as several related hypotheses testing. We also provide comparative empirical results for both the proposed model and that of Hyytinen et al. (2016) using a sample of EU Farm Accounting Data Network (FADN) cotton farms in Greece.

T1- 5 DEA METHODS II

Chair: Tatiana Bouzdine-Chameeva

ABSTRACT Nº: [164] - PRODUCTION TRADE-OFFS IN MODELS OF DATA ENVELOPMENT ANALYSIS WITH RATIO INPUTS AND OUTPUTS: AN APPLICATION TO SCHOOLS IN ENGLAND

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Inputs and outputs represented by ratio data (such as percentages and averages) often appear in efficiency applications along with volume data. As well known, such measures are inconsistent with the basic assumptions (axioms) on which the conventional variable and constant returns-to-scale (VRS and CRS) models of technology are based. The ratio-VRS (R-VRS) and ratio-CRS (R-CRS) models developed by Olesen, Petersen, and Podinovski (2015, 2017) address this issue and allow the incorporation of both volume and ratio inputs and outputs. In this paper, we extend the R-VRS and R-CRS models by accommodating additional production trade-offs between volume inputs and outputs and, similarly, between ratio measures. The specification of production trade-offs provides additional information about the production process and improves the efficiency discrimination of the resulting R-VRS and R-CRS models. We use an application in the context of school education to demonstrate the usefulness of the suggested methodology.

ABSTRACT Nº: [163] - AXIOMATIC MODELING OF FIXED PROPORTION TECHNOLOGIES

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Understanding substitution (transformation) possibilities of inputs (outputs) is critical for efficient resource allocation and firm strategy. There are several important examples of fixed proportion technologies where some inputs and/or outputs are not substitutable. However, there is widespread confusion about appropriate modeling of fixed proportion technologies in data envelopment analysis. We point out and rectify some misconceptions in the published literature, and show how the fixed proportion technologies can be correctly incorporated into the axiomatic framework.

ABSTRACT Nº: [69] - CONVERGENCE OF CONVEX AND NON-CONVEX CENTRALIZED ALLOCATIONS IN NON-PARAMETRIC TECHNOLOGIES

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In recent years, the literature has witnessed a growing interest about the issue of centralized allocations - where the reference technology is obtained as the sum of firm technologies. Starr, in his seminal contribution on markets with quasi-equilibria, pointed out the key role that aggregation has in smoothing out non-convexities and granting the existence of these equilibria. We show that the Shapley-Folkman-Starr theorem can be employed to establish an analytical proposition about the convergence of convex (i.e. DEA) and non-convex (i.e. FDH) centralized allocations when the aggregate technology is determined as the sum of individual identical technologies. The proposition holds under pretty general assumptions. Several multiple input and output datasets, and a numerical example, are used to illustrate the theoretical result and the rapidity of convergence under different circumstances. The results

obtained suggest that the assumption of a convex technology, which is generally unjustified at the firm level, can be given a space-divisibility interpretation at the group level.

ABSTRACT Nº: [71] - OPTIMAL INPUT AND OUTPUT WEIGHTS IN MULTIPLIER DEA MODELS

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he interpretation of optimal input and output weights in the conventional multiplier CRS and VRS models is well known. For example, the optimal weights in the CRS model are the most favourable for the DMU under the assessment in comparison to all observed DMUs in two respects. First, such optimal weights maximise the ratio of the weighted sum of outputs to the weighted sum of inputs, provided no observed DMU can have such ratio exceeding unity. Second, we can interpret the weights as input and output prices, in which case the difference between the weighted sums of outputs and inputs is the profit made by the DMU. Any optimal weights of the multiplier CRS model maximise the profit made by the DMU under the evaluation, provided the maximum profit over all observed DMUs is equal to zero. Additionally, it is also known that any optimal input and output weights represent the normal vector of a supporting hyperplane to the technology at the projection of the DMU on the boundary, which is found in the chosen orientation on which the model is based.

In this paper, we explore the meaning of optimal input and output weights, and any other components of optimal solutions, of multiplier DEA models based on a range of different polyhedral technologies, of which the standard VRS and CRS technologies are two common examples. Other examples include multicomponent technologies, technologies incorporating weight restrictions, technologies with restricted input and output measures, hybrid returns-to-scale technologies, technologies incorporating weak disposability of inputs and outputs, and network technologies with several stages. Multiplier models based on such technologies often have complex structures and employ a range of different variables whose exact meaning is unclear. We explore this issue and show that, for all polyhedral technologies, the optimal input and output weights still maximise the ratio of the weighted sums of outputs and inputs, and the profit efficiency of the DMU under the evaluation. However, this maximization is no longer performed with respect to all observed DMUs but is undertaken with respect to all DMUs in the entire assumed technology. This result allows a meaningful interpretation of a range of multiplier models based on different technologies.

T1- 6 REGULATION II

Chair: Per J. Agrell

ABSTRACT Nº: [154] - ADDRESSING HETEROGENEITY IN REGULATORY BENCHMARKING WITH DECENTRALIZATION

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Facing heterogeneous operating conditions for their operators, some regulators are unwilling to use frontier analysis from larger datasets due to the risk of biased or infeasible estimates. A federal regulator may decentralize the assessment to a lower level in order to improve the precision. An example is Belgium, where three regional regulators use three different methods for evaluating their distribution utilities for gas and electricity. In other countries, such as Germany, the regions (Bundeslander) delegate the estimation task upwards to the federal level to get a higher quality, then decides whether or not to exercise regulatory discretion. We challenge both approaches based on the social cost of information rents to regulated units, discussing in detail certain documented approaches to partition the reference set and their consequences. We find some empirical bounds for the information rents and also suggest some alternative methods to accomodate the concerns of heterogeneity without jeopardizing the information wealth in DEA.

ABSTRACT Nº: [223] - CONDITIONAL QUANTILE ESTIMATORS OF UNIT INEFFICIENCY IN STOCHASTIC FRONTIER ANALYSIS, WITH APPLICATION TO ELECTRICITY DISTRIBUTION MARKET

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Only an accurate estimation of unit (in)efficiency makes the stochastic frontier analysis (SFA) an appealing estimation technique for regulators. In the SFA literature, the conditional mean/mode estimators of inefficiency are the most common unit inefficiency estimators. However, they shrink towards the mean/mode inefficiency rather than towards the actual unit inefficiency, especially in presence of noise variance inflation. We propose the conditional quantile estimators of unit inefficiency instead, and analytically show that they also shrink towards the quantiles of inefficiency rather than towards the unit inefficiency— a fact that can be seen as an advantage in total contrast to the disadvantageous shrinkage property of the conditional mean/mode, when we show how accurately the quantile of each unit inefficiency is estimated. An extensive simulation study is conducted to assess the performance of the new estimators, in parallel with an application of the methodology to some real data from Swedish electricity distribution network.

ABSTRACT Nº: [243] - INCENTIVE MECHANISMS IN ECONOMIC REGULATION: Motivation and practice

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Economic regulation in its main manifestations takes the form of a state agency, collectively referred to as the “Regulator”, imposing inter alia price or revenue caps for the goods or services supplied by the regulated entities. Regulatory systems of this type are aimed to protect the

consumers (clients) of the regulated entities both in terms of not being charged excessive prices while at the same time ensuring continuity of supply of said goods and services.

The talk will explore past, current and potential new incentivisation mechanisms in economic regulation. The need for incentives stems from the asymmetry of information between the regulator and the regulated entities. Each regulated entity is responsible for its own day to day management while providing the regulator data at its discretion and what the state permits the regulator to access. From such data the regulator needs to ascertain any scope for cost savings. The regulated entity on the other hand, often under lack of product differentiation and de facto monopoly power, has no inherent incentive to devise ever more efficient practices, when those inefficiencies can in effect be 'funded' by the consumer. The regulated entity's managers could implicitly aim for what Bogetoft and Hougaard (2003) referred to as 'rational inefficiency'. It is therefore incumbent upon the regulator to devise regulatory mechanisms which will incentivise regulated entities to strive for ever more efficient operating practices for the ultimate benefit of the consumer whose interests the regulator serves. The talk will cover both explicit and implicit regulatory incentives, including those implicit in the choice of modelled costs, activity level variables, and maintained returns to scale assumptions and notions of outlier performers and their treatment. The underlying rationale and working of certain implemented incentive mechanisms will also be covered.

T2- 1 SUSTAINABILITY AND ECO-EFFICIENCY I

Chair: Emili Grifell - Tatjé

ABSTRACT Nº: [209] - ENERGY CONSUMPTION AND CO2 EMISSION: EVIDENCE FROM EFFICIENCY ANALYSIS ACROSS EUROPEAN COUNTRIES USING A LONG PANEL

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Several countries in Europe have introduced energy-efficiency targets with the objective to reduce their overall energy consumption and carbon emissions. In this paper, we use the stochastic frontier approach to estimate the level of inefficiency in overall and per capita energy consumption and CO2 emission across 17 European countries. To this purpose, we make use of a rich panel data over 25 years (1995 to 2019) consisting of aggregate country level measures. Our dataset consists of annual figures on final energy consumption, CO2 emissions, energy prices, share of exports and imports, as well as the fossil fuel mix in the gross available energy. Additional sector information, such as share of consumption across industrial, transport and residential sectors, and public transport modal split are included. We also control for weather components and other relevant country level indicators such as population, GDP and political orientation.

Given the rich dataset, we used multiple specifications using several SFA models. Our preliminary results find notable persistent inefficiencies in the (per capita) final energy consumption and CO2 emissions. The inefficiencies appear to be somewhat stronger in the industrial sector. The results from sectoral analysis also hint towards an important positive role of the public transport modal split across these countries. The high level of persistent

inefficiency is indicative of structural hurdles faced by some of these countries in achieving their energy-efficiency targets. As next steps, we plan to deploy other approaches that may help explain the reasons behind the level of inefficiencies to shed light on potential policy implications. We also plan to obtain relative rankings of the countries based on our efficiency estimates.

ABSTRACT Nº: [102]- ENHANCING THE MEASUREMENT OF FIRM INEFFICIENCY ACCOUNTING FOR CORPORATE SOCIAL RESPONSIBILITY: A DYNAMIC DATA ENVELOPMENT ANALYSIS FUZZY APPROACH

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This paper contributes to research on the corporate social responsibility (CSR) field and the inefficiency measurement of firms by proposing a new method for evaluating inefficiency accounting for firms' CSR activities. The new approach considers the imprecise nature of CSR data through the fuzzy data envelopment analysis (FDEA) method and further extends it by allowing for the dynamic interdependence of firms' production decisions through adjustment costs, related to firms´ investments. In addition, the new method deals with zero or negative values for inputs and/or outputs of the data. The empirical application used in this paper considers a dataset of CSR activities of European firms for three industries (capital, consumption, and other) over the period 2014–2016. Two main results are found with this data. First, the study shows that fuzzy dynamic inefficiencies tend to be lower than these obtained from the conventional crisp evaluation of inefficiency. Second, the study finds some differences in dynamic inefficiencies at distinct levels of fuzziness. Overall, the results seem to confirm that the usage of dynamic fuzzy methodology adds some value to the standard crisp approach.

ABSTRACT Nº: [110]- GREEN TOTAL FACTOR PRODUCTIVITY: QUANTILE SHADOW-PRICE FISHER INDEX APPROACH

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Measuring green total factor productivity (GTFP) is widely recognized as a longstanding challenge to economists and of extreme interest to policy-makers. This paper proposes a quantile shadow-price Fisher index to gauge GTFP change. The developed penalized convex quantile regression approach yields the unique shadow prices estimates, takes inefficiency explicitly into account, and is more robust to outliers and the choice of the direction vector. The proposed quantile shadow-price Fisher index does not require the real price data, can avoid an ad-hoc choice of quantiles, and allows the quantiles to move in the inter-period sample. An empirical application to OECD countries during 1995--2019 confirms that the quantile shadow-price Fisher index generally yields a good approximation of the conventional Malmquist index and is a better choice for measuring GTFP change.

ABSTRACT Nº: [52] - BUSINESS VALUE CREATION INCORPORATING ENVIRONMENTAL, SOCIAL AND GOVERNANCE INDICATORS

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Much has been written about the shortcomings of profit as a measure of business social performance, and of GDP and similar economic indicators as measures of aggregate social performance. While profit is an adequate measure of a business' financial performance, it excludes a range of externalities, positive as well as negative, a business creates, and while GDP is an adequate measure of an economy's economic output, it excludes externalities, also positive as well as negative, resulting from the production activities that generate GDP. While these arguments have become influential, they lack an analytical framework that would enable the statement of refutable hypotheses and empirical testing of these hypotheses. We provide such an analytical framework of social value creation within which to study business value creation and distribution, both internal to capture the distribution of its added value to its owners and other stakeholders and external to capture the distribution of its added value society's stakeholders.

T2- 2 HEALTH II

Chair: Ana Rodriguez-Alvarez

ABSTRACT Nº: [235] - DETERMINANTS OF TECHNICAL EFFICIENCY IN LONG-TERM CARE PROVISION – A HOLISTIC AND MULTIVARIATE DOUBLE BOOTSTRAP DEA APPROACH

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This paper examines the determinants of technical efficiency in long-term care provision using a primary data set comprising public and private Irish nursing homes. To elucidate the heterogeneity evident in the performance of care providers, this research applies a holistic multivariate modelling approach by integrating three types of potential determinants in estimating and explaining technical efficiency: (1) ownership status; (2) nursing home characteristics; and (3) quality indicators. The analysis is input-oriented and considers a case-mix adjusted efficiency model. The comprehensive set of efficiency determining variables investigated includes ownership; size, age and other inherent firm characteristics, together with output characteristics of nursing homes such as case-mix. as measured by the high-maximum dependency rate, and chain status; as well as numerous structural quality-related factors which mostly concern labour management within nursing home long-stay units. The approach employs the semi-parametric double bootstrap DEA method which enables robust estimation of both technical efficiency and its determinants. The facilities in this study are found to be only 54% technically efficient on average, and ownership has a significant effect on efficiency with private nursing homes being more efficient than public units. While some quality indicators (i.e. the medical to non-medical staff ratio, and the labour-capital ratio) increase efficiency in long-

term care provision, there is a trade-off between efficiency and other structural quality factors (i.e. staffing levels and staff flexibility). We also find that Irish nursing homes are scale inefficient, and that they should decrease their size and scale of operations to become fully productive.

ABSTRACT Nº: [234] - PERFORMANCE ASSESSMENT OF THE ITALIAN HEALTHCARE SYSTEM USING CONDITIONAL NONPARAMETRIC EFFICIENCY MODELS

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Conditional frontier models, including full and partial, robust frontiers, have fast evolved into an indispensable tool for exploring the impact of exogenous factors on the performance of the Decision Making Units in a fully nonparametric setup. The conditional nonparametric framework enables the handling of heterogeneity in a formal way, allowing to explain the differences in the efficiency levels achieved by units operating under different external and/or environmental conditions. Moreover, conditioning on time allows to take into account time delays and adjustment costs and to obtain more reliable estimates of performance among units.

In this paper we show how this nonparametric dynamic framework is important to evaluate efficiency in the healthcare sector. We provide numerical illustrations on a dataset from the Italian healthcare system, including summaries of practical implementation details.

ABSTRACT Nº: [80] - COST EFFICIENCY FUNCTIONS AND DETERMINANTS OF COSTS IN IRISH PUBLIC HOSPITALS - A PANEL DATA APPROACH

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The effective utilisation and allocation of scarce resources provided by the taxpayer for the delivery of public health services is a foremost concern for policymakers in many countries. The Irish hospital system presents an interesting case study as it demonstrates issues with unmet demand in acute hospital care, as evidenced by the number of inpatients treated on a trolley bed, along with very high waiting lists for specialist treatment. Moreover, Ireland has the second-highest health spending ratio in the OECD area, yet the recent data suggest that the level of public hospital bed occupancy is estimated to be the highest amongst OECD countries at 95%. Therefore, the aim of this study is to examine if there is a scope for improvement in the cost efficiency in the Irish public hospital system and hence a reduction of excess costs, whereas the additional cost savings could be utilised in other areas of public hospitals such as the capacity improvements.

This paper applies a novel monthly panel data set for 36 acute hospitals over the 2 year time period from 2017 to 2019 (n= 864). This rich and unique data set was acquired through public

sources as well as directly from the Business Information Unit of the Health Service Executive (HSE) in Ireland. To measure the cost efficiency of Irish hospitals, parametric SFA techniques are applied which control for both the inefficiency component and noise, while the panel data allow us to control for both the unobserved and observed heterogeneity of hospitals. Moreover, we apply the generalised true-random effects SFA panel data method to distinguish between the persistent and transient cost inefficiency. A trans-logarithmic cost function is used which provides consistent skewness parameters for the estimation of efficiency and proves to be a better fit than the Cobb-Douglas equivalent. For the dependent variable, we use the total variable costs of hospitals - this variable is measured by the monthly total budget spending for each hospital in the given month. We model costs as a function of three outputs (case mix-adjusted inpatient discharges, case mix-adjusted day-case discharges, and outpatient appointments) and two labour input prices (monthly full-time adjusted salaries of medical and nursing staff). Importantly, we also include other hospital characteristics directly in the cost function to account for their observed heterogeneity - such as the hospital group, the hospital model type, and the share of private practice in Irish public hospitals.

The transient average cost efficiency (CE) is about 0.97 and the time-invariant CE is lower at 0.95, meaning that the cost inefficiency in Irish hospitals could be reduced by 3% to 5%. As expected, case mix-adjusted inpatient activity provides the greatest output elasticity with respect to costs. Interestingly, there is a negative relationship between the number of beds and costs - perhaps an indication of the capital constraints inherent in the underlying process. Hence, efficiencies may be available with increased bed capacity - i.e. as the number of beds increases, we expect to see a decline in the overall cost profile. We also find statistically significant differences in hospital costs depending on the hospital type (representative of hospital technology), and group (representative of structural/management performance). Hence, we derive a number of findings that have important implications for policymakers.

ABSTRACT Nº: [90] - THE COST OF THE POOR QUALITY IN HEALTH CARE

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Regarding quality, its effect on hospital activity is ambiguous. In fact, the literature on the subject is inconclusive and even contradictory. Although, in principle, it could be thought that higher quality implies a higher investment in productive factors and, therefore, a higher cost this relationship is not clear (Ferreira et al., 2020).

The aim of this paper is to shed some more light on this issue by analysing how failures in the quality of hospital care affect the activity of hospitals. For this purpose, it has been taken into account that hospitals may have heterogeneous discharges: on the one hand, discharges corresponding to patients who have completed their healing process in hospital and, on the other hand, discharges resulting from patients who have been discharged too early and will therefore be readmitted to hospital. In the first case, discharges are more resource-demanding (as they involve more days of hospitalisation, ceteris paribus, and may involve more complications in terms of hospital infections); in the second case, the patient returns with the consequent additional use of resources. There is therefore a trade-off between the decision to discharge at the end of full cure or earlier. Which is more costly for the hospital?

To answer this question, in this paper we propose a novel model that permits to understand the effect on technology and hospital costs of poor health care, taking into account the heterogeneity of output, and the possible endogeneity of quality of care (Amsler et al., 2017). This model, based on SFA and the dual theory between distance and cost function, can be used to overcome the problems posed by the models previously applied in the literature.

In its empirical application, a panel of hospitals belonging to the NHS observed in the period 2002-2016 is used. The results obtained allow us to conclude that hospitals with more readmissions require a greater use of resources. That is, treatment required by a patient who is readmitted (more tests, potential stays in the ICU...etc.) is more expensive than keeping the patient a few more days under observation to achieve a definitive discharge, which makes sense considering that the last days of hospital stay are the least demanding in resources and therefore, the least costly. Moreover, this additional cost follows an increasing temporal trend, especially in times of expansion when the use of resources is greater.

Given that the results indicate that readmissions imply an additional cost for the hospital system, they must be contained. In fact, readmission rates are a significant component of current quality improvement strategies. Therefore, knowing their cost can be relevant for the design of policies that seek to penalize hospitals with high readmission rates (Gupta, 2021).

T2- 3 SFA APPLICATIONS III

Chair: Christopher Parmeter

ABSTRACT Nº: [186] - THE IMPACT OF COVID-19 ON EUROPEANS' ECONOMIES: FIRST AND SECOND-ORDER SUPPLY AND DEMAND SHOCKS

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We examine in this paper the economic and welfare effects of the COVID-19 pandemic for a set of European countries. Our empirical model is developed using the theoretical framework introduced by Caliendo et al (2017). This framework allows us to both control for sectoral heterogeneity and for trade-related effects caused by differences in the relative opportunity costs of producing intermediate inputs among countries. Our econometric specification also accounts for technological spillovers through the linkage of industries. The frontier specification of our production model permits simulating the deterioration in capacity utilization due to factory closures attributable to the COVID-19 outbreak.

The main contribution of the paper is to provide an analytical framework that helps to simulate not only immediate supply and demand-side effects, but also a variety of second-order effects that consider the international supply chains and the feedback loops in the economy, e.g. shortages of materials, the deterioration of the benefits of international trade and the blockage of technology diffusion. We also try to simulate the feedback loops in the economy using a multi-stage procedure.

To perform the analysis for the 28 European countries considered, we use data from two different sources: EU KLEMS and World Input-Output Database. Using the information available

in EU KLEMS for the period 1995-2017 we obtain data for capital, labor, and intermediate inputs, as well as gross output and value-added. Making use of the information on intercountry trade flows from WIOD, we can compute some key parameters such as the bilateral trade shares, the regional trade surpluses, the shares of value-added in gross output and final consumption shares by sector and country.

ABSTRACT Nº: [86] - A STOCHASTIC MULTICRITERIA ACCEPTABILITY ANALYSIS OF CUSTOMER SATISFACTION WITH LUXURY 5-STAR HOTELS LOCATED IN FIVE EUROPEAN CAPITAL CITIES

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Tourist satisfaction plays a vital role in the performance of hotels. It is paramount to determine what the customer's value the most in these hotels and how to classify each satisfaction criterion (featuring the hotel attributes). One would also need to know how demanding the customers are, and what are the potential improvements, priorities, and opportunities of the hotels to improve their performance. Europe is one of the most visited regions in the world, accounting for nearly half of international tourist arrivals. Hence, this paper considers a sample of luxury 5-star hotels in five European capital cities to study the determinants of customer satisfaction. We used a multicriteria satisfaction analysis (MUSA) to conduct such a study. Because of the data nature, we introduced the Stochastic Multicriteria Acceptability Analysis. Therefore, the problem of imperfect knowledge of data used in MUSA can be surpassed. MUSA outcomes become stochastic, allowing future statistical inference, which is not possible in deterministic MUSA. Results point out an enhancement of food as the highest priority. However, strategies, priorities, and opportunities may depend on the city under analysis.

ABSTRACT Nº: [206] - DISENTANGLING THE EFFECT OF CONSUMER BEHAVIOR AND TECHNOLOGY ON REDUCING WATER CONSUMPTION: A LATENT CLASS-STOCHASTIC FRONTIER

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Reducing consumption may be an important tool to avoid water shortage at least in those places characterized by a dry climate. This consumption reduction may arise from two main sources: consumer environmentally awareness to avoid wasting water (adopting some recommended practices), and the use of more efficient water appliances and other devices to reduce water consumption. However, disentangling the contribution of those sources to water consumption reduction may be difficult due to the correlation between them: highly aware consumers tend to use devices more efficiently to reduce consumption.

Our hypothesis is that water consumption awareness leads to different consumers` behavior and, then to different classes of consumers. On the other hand, the better devices in order to saving water are assumed to be effective independently of the kind of consumer using them. Our proposition is the use of a latent class-stochastic frontier model to identify the effect of the two sources of water consumption reduction. Different kind of consumers will have different water demand which may be understood as different classes of consumers. On the other hand, the use of housing appliances and other devices are considered as efficiency determinants in the demand for water of any class of consumer.

To carry out the empirical analysis, we have information on a random sample of consumers located in the city of Gijon (Spain), along the period 2017-2021. This sample includes information from different sources. A field survey was conducted by the end of 2020, collecting information on several socioeconomic features, housing equipment, attitudes towards the environment and conservation habits. The water supplier company in Gijón (EMA) provides information on water consumption and prices.

ABSTRACT Nº: [137] - NONPARAMETRIC ESTIMATION OF STOCHASTIC FRONTIER MODELS WITH WEAK SEPARABILITY

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We propose a robust and versatile approach to estimate the stochastic frontier model which eschews parametric assumptions. Our approach requires a single continuous covariate that influences only and has a monotonic relationship with the conditional mean of the inefficiency term. Subject to these conditions, the frontier and the conditional mean of inefficiency can be estimated fully nonparametrically. The estimator we propose only relies on local least squares and marginal integration making it easy to implement across statistical software. A range of Monte Carlo Simulations suggests that when our main identification condition holds, our proposed estimator outperforms other proposals that currently exist. Finally, we provide a timely application to the study of undercounting COVID-19 cases across the United States. Whereas our method documents substantial undercounting, consistent with the broad scientific community, other nonparametric methods suggest far less undercounting.

T2-4 MULTI-METHODS III

Chair: Camilla Mastromarco

ABSTRACT Nº: [18] - PERFORMANCE GROWTH THROUGH A MULTI-HIERARHY OF TECHNOLOGIES AND SPILLOVERS. IS LEARNING FACILITATED BY ADOPTING GREENER TECHNOLOGIES?

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Sustainable Development Goals and the recent European Green Deal set sustainable production as one of the priorities in fostering green growth facilitating the sustainability transition by preserving scarce natural resources. However, country economies face uneven opportunities in implementing green technologies as those might not have access to those. Acknowledging the uneven development levels across the globe, in this paper we introduce a conceptual approach including a multi-hierarchy of production technologies employing a non-parametric metafrontier Data Envelopment Analysis. These technologies are characterized by technological complexity, heterogeneity and variety based on alternative shades of green production and learning grids. Thus, we put forward multiple scenaria based on the productive assets included in the production process to investigate production possibilities that could support and facilitate the sustainability transition. This particular setting allows us to explore whether the nature and effect of spillovers generated influence performance change across development levels. We apply our conceptual approach using a dataset including 104 country economies over a nine year period, that is from 2006 through 2014. Econometric results of fractional probit models estimation to explore performance differentials between production scenaria, indicate that performance changes across scenaria are indeed attributed to knowledge flows, circulating in each learning grid, associated with green technologies, however only up to a certain extend. Therefore, green technologies are a necessary but not sufficient condition for sustainability transition. Findings indicate that resource endowment, regulatory framework, as well as absorptive capacity exert an influence on performance change across hierarchies while the use of renewables seems to be pervasive across hierarchies.

ABSTRACT Nº: [33] - RESOURCE USE EFFICIENCY AND AGRICULTURAL SUSTAINABILITY: EVIDENCE FROM NORWAY

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In recent years, research in agriculture has intensified because of concerns over the current system's sustainability. Farm businesses are encouraged to adopt sustainable choices and behaviors to prevent environmental deterioration while maintaining long-term food security and optimizing production resources. The evaluation of resource use is critical for the sustainable development of the agricultural sector. This article reviews the methods used in the literature to measure the performance of farm resource use for the sustainable development of the agricultural sector. Using Norwegian dairy and crop farms as a case study, we illustrate the possibility of improving the agricultural sector and reducing resource waste. Based on the empirical results of the case study, dairy and crop producers used the technology as suboptimal and lost production resources. If all farmers follow a sustainable and efficient path to produce agricultural output, they could reduce the use of production resources by 15-18%. Farmers need to follow sustainable pathways, and policymakers should facilitate experience sharing among farms so that less efficient dairy and crop-producing farms can learn from the most efficient farms.

ABSTRACT Nº: [108]- SUBSAMPLING BOOTSTRAP IN NETWORK DEA: MONTE CARLO EVIDENCE

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Data Envelopment Analysis (DEA) provides an empirical estimation of the production frontier based on an observed sample of decision making units (DMUs). Except for the single input-single output case, the asymptotic distribution of the DEA estimator can only be approximated through bootstrapping approaches. Therefore, bootstrapping techniques have been widely applied in the DEA literature to make statistical inference for the cases when the production process has a single-stage structure. However, in many cases, the transformation of inputs into outputs has an inner structure that needs to be considered. This study examines the applicability of the subsampling bootstrap in the estimation of the true production frontier, when the production process has a network structure, and in the presence of undesirable factors. Evidence on the performance of subsampling bootstrap is obtained through Monte Carlo experiments for the case of two-stage series structures, where overall and stage efficiency scores are calculated using the additive decomposition approach. Results indicate great sensitivity both to the sample and subsample size, as well as to the data generating process. Subsampling methodology is then applied to construct confidence interval estimates for the overall and stage efficiency scores of railways in 22 European countries, where the railway transport process is decomposed into two stages and the railway noise pollution problem is considered as an undesirable output.

ABSTRACT Nº: [155] - EFFICIENCY NETWORK IN THE EU

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By extending a new approach to model spatial heterogeneity, we consider both strong and weak spatial dependence in an efficiency frontier heterogeneous panel data model. By using a dataset of EU regions from 1980 to 2019 we explore the channels under which efficiency fosters productivity by disentangling the impact of spill-in and spill-out efficiency externalities. We emphasize the usefulness of taking into account heterogeneous spatial dependence in production technology to better analyze the importance of production networking on productivity growth in EU regions. Our main result show that income per capita across EU regions is spurred by regional production efficiency network.

T3- 1 SUSTAINABILITY AND ECO-EFFICIENCY II

Chair: Renata Oliveira

ABSTRACT Nº: [153] - TECHNICAL EFFICIENCY OF WATER RECOVERY PLANTS FROM A CIRCULAR ECONOMY PERSPECTIVE

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Located in the center-west of the Argentine Republic on the Andes mountain range, the province of Mendoza is characterized by an arid climate, with scarce flows in its rivers and irrigated basins that receive an annual average of 230 millimetres of rainfall. The province is experiencing its 13th consecutive year of water crisis.

This water situation undoubtedly forces agricultural producers and the public system to be more efficient in the use of scarce natural resources, aiming to minimize production losses both in quality and quantity, which can consequently the profits of agricultural companies and the society in general. Failure to adapt will result in a detriment to production with possible abandonment of agricultural activity and/or a decrease in the price of property for productive purposes.

The reuse of the water resource is an alternative to the unsatisfied demand for agricultural irrigation (596-1,155 hm3 per year) and contributes to the revaluation of the resource.

AySAM is a state-owned company that has 21 purification facilities that treat 4,000 l/s from 350,000 connections and irrigate 3,600ha. The operation of these facilities exceeds the original design capacity, by an average of 80%. This situation implies additional costs in operation and maintenance, deterioration of the infrastructure and compromises technical and managerial decision-making.

The productive performance of the wastewater treatment plants (WWTPs) is analyzed by employing non-parametric techniques. Irrigation, decision-makers at AySAM, and stakeholders would benefit from having a better understanding of which of these approaches would cost-effectively address this series of problems considering future uncertainties.

ABSTRACT Nº: [14] - TECHNOLOGY HETEROGENEITY AND SUSTAINABILITY EFFICIENCY: EMPIRICAL EVIDENCE FROM PERUVIAN RICE AND COFFEE PRODUCTION

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Peru can be divided into distinct natural regions - namely Costa, Sierra, and Selva - where farming systems differ because of variations in agroclimatic conditions, market integration, and other factors. This article uses a non-parametric non-convex metafrontier approach to estimate sustainability efficiency of rice and coffee farms in Peru while considering heterogeneity in production technologies that exist among the country's natural regions. Sustainability efficiency measures reflect farmers' ability to increase production of desirable agricultural outputs (technical efficiency), reduce fertilizer-induced N2O emissions (environmental efficiency), and create employment opportunities for women (social efficiency). The empirical application uses data on 1,142 and 1,124 rice and coffee farms, respectively, over the period 2017-2019.

We make four contributions to the literature. First, we are the first to measure farm-level sustainability efficiency in Peru, and in a developing country context more generally. Second, this is the first study to measure social efficiency in terms of farmers' contribution to employment opportunities for women. Employment of women and other less empowered or marginalized people is viewed as an important social service by the social farming literature (e.g. García-Llorente et al., 2017). Apart from the agricultural literature, the corporate social responsibility literature views the number of women employed as an indicator of a firm's neighborhood and social responsibility (Chambers & Serra, 2018). In a world where issues of gender equality and women's participation in economic activities are becoming important national and international focal points, research on such issues can be instructive to legislators in obtaining valuable feedback than can guide future policy interventions. Third, we show how the factor band principle developed by Dakpo (2015) can be used to link three different sub-processes of a production system (i.e. operational, environmental, and social). Finally, most studies using nonparametric metafrontier models to measure farm efficiency under technology heterogeneity adopt a convexification strategy by estimating the metafrontier as the non-parametric boundary of a convex metaset (e.g. Latruffe et al., 2012). This strategy is normally not true and generally leads to erroneous results, as shown by Kerstens et al. (2019). Therefore, in line with Kerstens et al. (2019) recommendation, a non-convex metafrontier approach is used in this study.

Results indicate heterogeneity in production across both rice and coffee farms located in different natural regions of Peru. Rice farms operating in the Costa region were more technically and socially efficient than rice farms operating in the Selva region, with the latter group showing a higher environmental efficiency. In coffee production, farms located in the Sierra region outperformed farms located in the Selva region in all three dimensions of sustainability efficiency. Our results offer insights to stakeholders interested in improving sustainability performance in Peruvian rice and coffee production.

ABSTRACT Nº: [140] - WATER CONSERVATION AND FARM PERFORMANCE: AN ECO-EFFICIENCY ANALYSIS OF GREEK GREENHOUSE FARMS

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The protection of water resources is widely acknowledged as one of humanity´s most critical issues and a major goal of EU waters as envisaged in the European Water Framework Directive and the UN Sustainable Development Goals (SDGs). Endangered water security, including both quantity and quality, has a detrimental impact on SDGs related to food security, water scarcity, climate change, biodiversity loss, and health risks.

With the agricultural sector being the largest user of freshwater withdrawals, sustainable agricultural practices are needed to ensure food security while promoting water conservation, especially in the presence of climate change. However, to support a sustainable and profitable agricultural sector, policy strategies need to be designed in terms of agricultural economic performance, environmental protection and equity. Thus, an empirical investigation of the trade-offs between economic and ecological agricultural activities is required to identify the optimal choices of farmers when it comes to produce more with using less. Given the different

production technologies characterizing agricultural production, it is important that such an analysis accounts for the different technological and environmental parameters that can affect irrigation water effectiveness, but also determine agricultural economic performance.

In this study, we are focusing on greenhouse farms producing vegetables in the area of Ierapetra in Crete, Greece, while all of the farms are equipped with different micro-drip irrigation technologies. The semi-arid Ierapetra Valley was chosen for the analysis of this study as it exhibits limited water resources and maintaining an adequate level of water quantity and quality reserves constitutes the priority for policymakers in the area. The objectives of the study are: 1) to incorporate economic decisions and water conservation strategies into a measure of eco-efficiency; 2) to study the trade-offs and synergies between farm technical efficiency and eco-efficiency; 3) to investigate the impact of alternative irrigation technologies (and other environmental determinants) on farm-level eco-efficiency using a two-stage DEA.

In this study, we apply an eco-efficiency framework as it allows us to incorporate both ecological and economic objectives of production activities. The economic dimension governs the production of desirable or good outputs, while the ecological dimension governs the water losses (undesirable outputs). The irrigation water effectiveness is used to estimate the undesirable output, water loss, which is defined as the difference between water application minus water absorption. All the greenhouse producers have in place drip irrigation systems, while some of them over the 4-year period of the dataset adopted an alternative irrigation technology, the overhead sprinklers. The overhead sprinklers are controlled automatically by moisture censors and timers and considered to be more water effective and to minimize evapotranspiration compared to the traditional drip irrigation systems. Thus, the adoption of the overhead sprinkler systems in the greenhouses of this semi-arid area of the Mediterranean basin is expected to minimize water loss, boost agricultural productivity and ease the water stress in the greenhouse production.

The production frontier was estimated non-parametrically using data envelopment analysis. The application focuses on a sample of 56 small-scale greenhouse farms in Crete for the cropping years 2009-2013. Results show a significant difference between calculated values for technical efficiency (0.810) and eco-efficiency (0.17), suggesting a substantial improvement potential in the water conservation behavior of farms. Furthermore, a bootstrap truncated regression model is used to evaluate the factors influencing the technical efficiency and eco-efficiency scores. These results have implications in terms of EU policy adjustment.

ABSTRACT Nº: [203] - THE ASSESSMENT OF BRAZILIAN MUNICIPALITIES ACCORDING TO THE SUSTAINABLE DEVELOPMENT GOALS

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This work conducted a performance assessment of Brazilian municipalities according to the sustainable development goals (SDGs) set by the 2030 Agenda. Traditionally, this sort of assessment takes as reference the quantification of the composite indicator (CI) named “Sustainable Municipalities Development Index – Brazil” (SCDI-BR), which aggregates 88 individual key performance indicators (KPIs). The official procedures for estimating the SCDI-

BR involve rescaleing the KPIs to ensure their comparability and aggregating of the indicators using an arithmetic average that assumes equal weights for the 17 SDGs. The alternative methodology proposed in this study estimates the weights using the Benefit-of-the-Doubt (BOD) approach for composite indicators based on Data Envelopment Analysis (DEA). The DEA-based model was specified with a Directional Distance Function (DDF) to incorporate in the assessment KPIs representing both desirable and undesirable outputs. The founding of this study can support a more in-depth understanding of the factors that impact the most the sustainable development in the municipalities in Latin American.

T3- 2 DEA APPLICATIONS III

Chair: Sérgio Santos

ABSTRACT Nº: [120] - A DYNAMIC ANALYSIS OF INDUSTRIAL ENERGY EFFICIENCY AND THE REBOUND EFFECT

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Energy efficiency improvement (EEI) is generally known to be a cost-effective measure for meeting energy, climate and sustainable growth targets. Unfortunately, behavioral responses to such improvements (called energy rebound effects) may reduce the expected savings in energy and emissions from EEI. Hence, the size of this effect should be considered to help set realistic energy and climate targets. Currently there are significant differences in approaches for measuring rebound effect. Here, we used a two-step procedure to measure both short- and long-term energy rebound effects in the Swedish manufacturing industry. In the first step, we used data envelopment analysis (DEA) to obtain energy efficiency scores. In the second step, we estimated energy rebound effects using a dynamic panel regression model. This approach was applied to a firm-level panel dataset covering all 14 sectors in the Swedish manufacturing industry over the period 1997–2008. We showed that, in the short run, partial rebound effects exist within most of manufacturing sectors, meaning that the rebound effect decreased, but did not totally offset, the energy and emission savings expected from EEI. The long-term rebound effect was smaller than the short-term effect, implying that within each sector, energy and emission savings due to EEI are larger in the long run compared to the short run.

A post-estimation analysis provides a guide to policy makers by identifying sectors where promoting EEI is more likely to have a desirable impact on the environment, energy savings and/or “sustainable” output growth. Our results suggested that different desirable outcomes can potentially be achieved by EEI in different sectors, mainly due to sector-specific characteristics such as CO2 emissions, energy consumption and output per unit of emission. We found that EEI had the largest positive impact on the environment, energy saving and “sustainable” output growth in Basic iron and steel, Pulp and paper and Electro, in that order. These results agree with earlier findings Amjadi et al., (2018) where were also found that EEI in Basic iron and steel and Pulp and paper results in, respectively, the largest CO2 emission savings and largest total energy savings in Swedish heavy industry.

ABSTRACT Nº: [40] - THE CONTRIBUTION OF INDUSTRIAL ROBOTS TO LABOR PRODUCTIVITY GROWTH AND CONVERGENCE: A PRODUCTION FRONTIER APPROACH

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We extend the nonparametric, production-frontier-based growth accounting approach (cf. Henderson and Russell, 2005) by incorporating industrial robots. We single out the contribution of robot capital accumulation to labor-productivity growth for the period 1999-2019 for a sample of 36 emerging and developed countries. By employing data envelopment analysis methods to construct the production frontier no specification of functional form for the technology nor any assumption about market structure or the absence of market imperfections is required. Our main results are as following:

(1) Productivity change is driven primarily by technological change (shifts of the production frontier) and non-robot capital accumulation. We find a positive contribution of robot capital accumulation to labor-productivity growth for almost all countries in our sample. However, considerable contributions of robot capital accumulation are found mainly in emerging countries, e.g., in India, China, Turkey, Mexico, Argentina, Brazil and in the Eastern European countries Hungary, Slovenia, Slovakia and Czech Republic. For developed countries the contribution of robot capital accumulation to labor-productivity growth is much less important, except for Israel, Canada and Norway.

(2) Compared to the growth accounting study by Cette et al. (2021) for a sample of 30 OECD countries, we find that the contribution of robot capital accumulation to labor-productivity growth for the period 2005-2019 is considerably lower for the majority of countries included in both studies.

(3) On average, labor-productivity grew faster in emerging countries than in developed countries (beta-convergence). Beta-convergence is primarily driven by non-robot capital accumulation and to a lesser extent by robot capital accumulation. While efficiency change (technological catch-up, movements toward or away from the frontier) might also contributed to beta-convergence, technological change is, on average, higher in developed countries than in emerging countries, and contributes to diverging levels of output per hour worked.

(4) The dispersion of productivity increased between 1999 and 2019 (sigma-divergence). While efficiency change works towards convergence (decreased variance), technological change is the main driver behind divergence (increased variance).

(5) The depolarization of the labor-productivity distribution between developed and emerging countries (a shift from a bimodal to a unimodal distribution) is primarily brought about by technological change. Statistical tests indicate that robot capital deepening and efficiency change significantly contributed to the depolarization of the labor-productivity distribution.

The qualitative results described above are robust i) to using different measures of robot capital, i.e., with respect to the method of constructing the robot capital stock and the assumed depreciation rate, ii) to different assumptions about the reference technology, iii) and the exclusion of outlier countries.

ABSTRACT Nº: [301] - BENCHMARKING AND PREDICTING THE DEMAND FOR A NEW DIABETES DRUG

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In this paper, we use benchmarking analysis and linear programming to evaluate existing diabetes drugs and to estimate the demand for a new drug. We benchmark the existing drugs in 2019 using data envelopment analysis (DEA) and show that some of the drugs are only marginally efficient. This finding suggest that they should be in limited demand. Using existing sales data, we next make partial inferences about the preferences that different patient groups have for the different drug attributes. Using this information, we can determine how the attributes of a new drug are likely to affect the demand for this drug. Likewise, we can estimate the share of the present users of the existing drugs that are likely to switch to a new drug.

ABSTRACT Nº: [180] - ASSESSING THE IMPACT OF COVID-19 ON THE PERFORMANCE OF PRIMARY HEALTH CARE SERVICE PROVIDERS: A CASE STUDY FROM PORTUGAL

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Primary health care (PHC) is usually the first point of contact for a person with the health care system and PHC providers are essential for effective disease prevention and management of chronic conditions. In Portugal, the primary health care sector has undergone a major reform since 2005 aimed at improving its performance.

The main objective of this study is to assess the effects of the COVID-19 pandemic on the performance of PHC providers operating under three different organizational models: Personalised Health Care Units (PHCUs), Family Health Units (FHUs) Type A and FHUs Type B; and on three performance dimensions: access to services, health management and disease management. To this purpose, we use Data Envelopment Analysis and the Malmquist Productivity Index and data from 907 PHC providers for the period 2018 to 2020.

The results show that while there was a significant deterioration in the performance of the providers from 2018 to 2020 in terms of access and disease management, an improvement in the health management performance was observed. The results also show that the pandemic caused by the novel coronavirus SARS-CoV-2 did not affect all the organizational model structures equally. Although the PHCUs underperformed in the three dimensions when compared with the FHUs, the deterioration in the performance of the former type of units, as a consequence of the pandemic, was not as significant as the deterioration in the latter. Equally, the results also indicate that the effects of the pandemic differed significantly across regions, with the PHC providers in the North displaying the best performance prior to the pandemic, but also displaying a considerable decrease in their performance as a consequence of it.

T3- 3 SFA METHODS II

Chair: Oleg Badunenko

ABSTRACT Nº: [211] - GENERALIZING DISTRIBUTIONAL ASSUMPTIONS IN SFA: WRONG SKEWNESS REVISITED

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The empirical problem of wrong skewness is known in SFA (which use compound error with symmetric observation error and one-sided inefficiency component, implying the 'correct' skewness). We elaborate the description by introducing more complicated alternatives for assumption violations under generalized distributional assumptions. We formulate the issue of 'wrong asymmetry' in more detail, taking as a starting point the generalized t for the symmetric error term and a generalized beta of the second kind (GB2) for the inefficiency term, and extend it into:

(1) A GT-GB2 model allowing for 'reverse inefficiency', with the inefficiency term added instead of subtracted, the direction is estimated and testable;

(2) A single error (hence non-SF) model with error term following skew asymmetric generalized t distribution, with a complicated pattern of asymmetry having more than just one source (e.g., skewness and tail asymmetry);

(3) A 'quasi-sfa' compound error model extending the GT-GB2 model by adding tail asymmetry (though not skewness) in the observation error.

Option (1) nests well-specified SF models and allows for 'reverse-inefficiency' formulation as the only alternative; (2) corresponds to the non-SF pattern of asymmetry; (3) combines properties of (1) and (2), yet goes beyond the usual SFA assumptions. Moreover, the framework allows for frontier specification checks. We use simulations to check the degree to which the 'true' asymmetry can deviate from the 'estimated' one (indicating that incorrect asymmetry is just a small sample issue), as well as check model robustness. Crucially, we investigate the importance of heavy tails in the process. We demonstrate how the framework in (1-3) can be used to analyze sources of assumption violations in real-life datasets.

ABSTRACT Nº: [237] - MAXIMUM CONCENTRATED LIKELIHOOD ESTIMATION OF THE STOCHASTIC FRONTIER MODEL

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The stochastic frontier model is typically estimated by the method of maximum likelihood. A related but distinct approach is to maximise the concentrated or profile likelihood, from which one or more nuisance parameters have been concentrated or profiled out. This approach can

have some advantages in terms of simplifying the maximisation problem, and in terms of the derivation of standard errors. A straightforward application of maximum concentrated likelihood estimation arises in the standard stochastic frontier model, but to our knowledge has yet to be explored. We compare maximum concentrated likelihood and maximum likelihood estimation of the standard stochastic frontier model, in terms of number of iterations and time taken to converge, stastistical properties, and standard errors.

ABSTRACT Nº: [161] - IRRIGATION METHODS, SHADOW VALUES AND PRODUCTIVITY: EVIDENCE FROM CHILEAN VINEYARDS

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The adoption of water saving technologies in agriculture has been proposed as a means to improve irrigation efficiency without having harmful effects on farm incomes (Huang et al., 2017; Zhang et al., 2019; Levidow et al., 2014). On average, pressurized systems are estimated to be 75-90% efficient in delivering water to crops compared to gravity systems, which have a 45-55% efficiency (Frisvold et al., 2018; Irmak et al., 2011). In addition, numerous studies have concluded that water saving technologies, such as pressurized systems, require less water to generate production levels comparable to those obtained from traditional systems (Huang et al., 2017). However, despite the potential benefits of pressurized irrigation, gravity methods (e.g., furrow, flooding) are much more prevalent than pressurized alternatives (e.g., drip, sprinklers, center pivots) in both developing and developed countries (Frisvold et al., 2018; Lanza et al., 2021; Masseroni et al., 2017).

This research focuses on the role of the quantity of irrigation water applied and the irrigation method used in explaining output in wine grape farms. We applied propensity score matching to reduce potential selection bias from observables that might mediate in the choice of irrigation system. Stochastic Production Frontier models are then estimated for a sample of 371 Chilean wine grape growers. The results show that pressurized irrigation leads to higher production at all levels of water applied; however, at lower levels the impact on TVP is more pronounced. Shadow values of water were calculated for an array of characteristics of the production unit, such as location, grape color, type of wine produced with the harvested grapes, irrigation method, and level of water applied. Shadow values calculated at observed output were not significantly different between pressurized (USD 0.026 $/m3) and gravity (USD $0.033/m3) systems. However, significant differences are found between low, (USD $0.046/m3), medium (USD $0.027), and high (USD $0.018/m3) levels of water applied. Irrigation productivity measures and corresponding water shadow values are critical in determining how water translates into agricultural output (Njuki and Bravo-Ureta, 2019). A number of the covariates included would act as shifters on the derived demand for water; thus, the associated parameters provide valuable information for guiding future public and private investments to foster greater water use efficiency and improved managerial performance (Ziolkowska, 2015).

The contributions of this study suggest questions that could be addressed in future work. An important area for further analysis is to collect robust panel data to enable the analysis of weather effects on grape production. As climate change intensifies and water supplies become

tighter, it is imperative to develop suitable research that can provide adaptive schemes to support wine grape production in Chile given the critical role that this subsector plays in the country's economy. Another area that needs attention is the quantification of water applied under gravity irrigation systems. This will entail careful fieldwork so that techniques can be developed and implemented at reasonable cost while generating reliable measures. This research in water use across different irrigation methods would benefit significantly by using the GPS position of the plots and then combining these data with secondary information gathered from Geographic Information Systems. For instance, soil and weather specific data would be helpful to control for natural factors affecting wine grape growing, which in this study could only be captured by the valley where the plots were located.

ABSTRACT Nº: [23] - IS THE PURSUIT OF SPORTING PERFORMANCE AND ACHIEVEMENT OF SPORTING SUCCESS IN THE ENGLISH FOOTBALL PREMIER LEAGUE INVESTMENT-FOCUSED?

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In this study, we empirically test the hypothesis that the sporting performance of the English football Premier League clubs is investment-focused i.e., based on wage spending. Different from previous studies that explain determinants of points obtained in a season, we analyze the rankings that clubs occupy in the league table. We employ the stochastic frontier model for an ordinal outcome and apply it to the data for over 9 seasons (20 clubs in each season) from 2011 to 2020. We find that matchday revenue is an important determinant of sporting performance. This is one of the reasons, clubs wish to play more matches at home. The results also suggest that wages that clubs pay to players appear to be an important factor behind sporting success. Further, the higher-ranked clubs have poorer ranking attainment (efficiency). The effect of relative wages (which we define as wages relative to the season average) is nonlinear. Increasing a relative wage is beneficial for ranking attainment and sporting success of the lower-ranked clubs and detrimental for ranking attainment and sporting success of the higher-ranked clubs. Overall results suggest that the English football Premier League has developed a relatively clear three tiers of clubs: those that participate in the (1) European Champions League, (2) Europe League Clubs, and the (3) other Premier League clubs that can relegate to the lower league and come back. These tiers have a very distinct ´´wage´´ or investment barrier, both in absolute and relative terms. If a club would like to switch up a tier a huge investment needs to be made. As for regulators, a wage/investment cap should be considered to enable a level playing field for all Premier League clubs.

T3-4 ENVIRONMENTAL EFFICIENCY

Chair: Charles-Henri DiMaria

ABSTRACT Nº: [167] - DO VEGETABLE QUALITY CERTIFICATES AFFECT ECO-EFFICIENCY OF SMALLHOLDER FARMS??

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This study empirically examines the impact of the vegetable quality certificates (pollution-less, green, and organic) on farms' eco-efficiency in China. The data was collected from 1175 vegetable growers in Shandong province by using the farm survey conducted in 2017 and 2019. To achieve the objectives of the study, the data envelopment analysis (DEA) is applied to estimate the smallholder farms´ eco-efficiency score which is defined as a ratio between economic value-added and environmental pressures including pesticide, plastic, chemical fertilizer, and utilities. The endogenous switching regression model (ESR), which has the advantage of correcting for the selection bias and heterogeneity arising from both observable and unobservable factors, is used to compare the eco-efficiency gaps between conventional farms and three different certificate-adopter groups. Organic vegetables performed the best in terms of eco-efficiency, followed by green vegetables and pollution-less vegetables, and conventional vegetables have the lowest scores. Meanwhile, we find the determinants of certificates adoption and drivers of eco-efficiency for different certificates adopters and give some policy recommendations based on the results. Therefore, it is necessary to promote the quality and safety certification of vegetables, which can not only ensure the commercial benefits of farmers but also contribute to the sustainability of the ecological environment.

ABSTRACT Nº: [30] - ENVIRONMENTAL REGULATION AND GREEN PRODUCTIVITY GROWTH: EMPIRICAL EVIDENCE FROM EU INDUSTRIAL SECTORS

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Climate emergency and environmental depletion have become an important issue for United Nations countries, and Governments are imposing stringent environmental regulation policies to move towards sustainable growth. In this scenario, pursuing a green growth requires firms to adopt new strategies in terms of energy saving, use of renewable power sources, and adoption of sustainable production processes. These changes have significant economic consequences for firms and industries, as a recent and large literature has pointed out. However, few studies have dealt with the role of environmental regulation at sectoral level. This paper contributes to this topic by investigating how environmental regulation affects productivity at sectoral level in a sample of selected European economies. Productivity growth is measured using Malmquist-Luenberger index, which is based on the Directional Distance Function (DDF). We find that environmental regulation policies have a negative effect on the productivity growth in several sectors of the manufacturing industry for almost all the countries included in analysis.

ABSTRACT Nº: [99] - HYPERBOLIC DISTANCE FUNCTION AND STOCHASTIC METAFRONTIER ENVIRONMENTAL EFFICIENCY

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This paper will develop a two-stage methodology combining a hyperbolic distance function and a stochastic meta frontier model to calculate the level of environmental efficiency and technology gap in 170 countries. We categorized these countries into five groups. Moreover, we will also determine factors that affect their efficiency using the Tobit model. (PM2.5, forest area, urban population, the proportion of the manufacturing value-added, the rule of law, government effectiveness, voice and accountability).

Data for Gross Domestic Product (GDP), population, labor, and capital are from Penn WorldTable 10.0. GDP and capital data have been calculated in constant 2017 US dollars, so the numbers have not been altered. Labor is the number of people employed in each country in millions. Energy is an integral part of the production process, and the energy consumption data are from the Energy Information Administration of the U.S.(EIA). In this study, we separate fossil energy consumption from non-fossil energy consumption. Fossil energy includes oil, coal, natural gas, and other liquids. Non-fossil energy has nuclear energy and other new renewable energy sources. Fossil fuels are a major source of greenhouse gases, so reducing fossil fuel inputs will reduce CO2 emissions and improve environmental efficiency. We will explain how to calculate these two variables in the following subsections. Raw energy consumption data are quad BTU, which we convert to million tons of coal equivalent (TCE) due to the enormous size of this unit.GHG emission data are from Emissions Database for Global Atmospheric Research v6.0, including carbon dioxide, nitrous oxide, and methane, as well as fluorinated gases. These gases are combined into one GHG indicator according to Global Warming Potential (GWP). This indicator reflects greenhouse gases released during economic production. We convert these data above to per capita data to avoid the effect of economic size heterogeneity on the measurement of environmental efficiency.

The calculation results show that the OECD countries group is leading in terms of intra-group efficiency, meta-efficiency, and environmental technology level. Furthermore, the three types of efficiency in the low-income countries are more different from the other groups. We also compared the efficiency calculated using the metafrontier method with the pooling method. It was found that the pooling approach underestimates environmental issues and does not capture the heterogeneity of the environmental problem. PM2.5 hurts environmental efficiency in all groups, indicating that while focusing on greenhouse gas emissions, attention should be paid to air pollution at the same time in order to improve environmental efficiency. Meanwhile, increasing the urbanization level in all groups can improve environmental efficiency. Urbanization can improve the industrial structure, promote technological progress, including environmental technology, enhance the region's overall development, and promote environmental efficiency improvement. In the analysis of forest area on environmental efficiency, we see that the increase in forest area is positively related to environmental efficiency in the OECD country group, but the opposite result is found in other groups. Forests have a potent greenhouse gas absorption and purification function, which positively impacts environmental efficiency in OECD countries. Many countries use forestry resources to increase their GDP in the other country groups.

ABSTRACT Nº: [231] - FROM ECONOMIC PRODUCTIVITY TO PRODUCTIVE WELL-BEING

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Productivity - a driver of economic growth -- does not imply societal well-being, nor environmental sustainability. Various authors contributed frameworks to incorporate environmental issues in the computation of productivity, or studied the role of well-being for productivity. However, studies proposing ways to account for both well-being and sustainability in productivity measurement are scarce. We check whether and to what extent it is possible to include subjective well-being and sustainability measures among the inputs and/or outputs of a traditional productivity framework. Specifically, we adopt a data-driven approach to test whether subjective well-being and adjusted net savings meaningfully contribute to computing a productivity-like indicator. We apply Data Envelopment Analysis to European data from 2005 to 2018. We find that including subjective well-being among the inputs and the outputs of production contributes to a measure of economic performance that accounts for quality of growth.

W1-1 AGRICULTURE V

Chair: Yashree Mehta

ABSTRACT Nº: [123] - ECO-EFFICIENCY OF AGRICULTURAL LANDSCAPES IN NORTH RHINE-WESTPHALIA, GERMANY

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Economic benefits of intensive farming are accompanied by adverse environmental and ecological effects including decreased soil and water quality, biodiversity losses, and reduced eco-functionality. Thereby, negative environmental impacts can be partly avoided through increasing eco-efficiency in pursuing sustainable pathways. Economic and ecological improvement potentials of such a transformation are, however, uncertain.

This paper analyzes ecological and economic improvement potentials of agricultural landscapes in the federal state of North Rhine-Westphalia, Germany. The state is a bioeconomy focus region characterized by a large agricultural sector with increasing intensification and bioenergy crop production. At the same time, the phase-out of lignite mining offers a transformation to a sustainable bioeconomy.

To identify locally adapted ecological improvement potentials at the landscape level, we derive an eco-efficiency model and apply robust non-parametric frontier estimation with a directional distance order-α estimator. This allows us to simultaneously estimate the frontier of best-practice combinations of ecological and economic outputs, and the landscapes' improvement potentials as the gap to this frontier. In a second stage, we plan using a flexible regression

approach to obtain a parametric representation of the frontier to evaluate trade-offs and co-benefits of ecological outputs, i.e., marginal rates of transformation for ecological outputs.

To represent the landscape level, we use a 20 km² hexagonal grid to cover North Rhine-Westphalia resulting in around 1.500 units. For each of these 1.500 hexagons, we derive ecological output indicators based on the Integrated Administration and Control System (IACS) to quantify landscape diversity (Shannon Index of crop diversity), landscape configuration (edge density), and landscape composition (share of grassland, share of ecological focus areas and landscape elements). To approximate the economic output potential, we use local standard farmland values, i.e. the average prices of agricultural land in the hexagon.

We find an overall high eco-efficiency of the agricultural landscapes in North Rhine-Westphalia with efficiency scores above 85% for 90% of the observations. That is, for the given level of economic outputs, landscape could increase all ecological output indicators simultaneously by around 5% on average. Results indicate no clear relation between average improvement potentials and the level of economic output. In addition, we identify potential conflicts and co-benefits within the ecological dimension. For instance, a low improvement potential (i.e. high efficiency scores) for the share of grassland relates to high improvement potential of the share of ecological focus areas and landscape elements. In summary, despite the overall high average eco-efficiency of the agricultural landscapes, results suggest substantial and spatially concentrated improvement potentials for single ecological outputs. In the next step, marginal rates of transformation for ecological outputs obtained from the second stage analysis (i.e., the parametric approximation of the frontier) will provide a better understanding of the trade-offs and co-benefits of ecological outputs.

ABSTRACT Nº: [166] - SUSTAINABLE EFFICIENCY OF ARABLE AGRICULTURAL PRODUCTION IN CHINA

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Considering the demand for food, increased costs in farming sector and a growing concern about agricultural pollutions in China, attention should be paid to combine a strong economic performance and a sustainable use of natural resources, as well as farmers' welfare. The purpose of this paper is to evaluate the sustainable efficiency, that is technical, environmental, and societal efficiency of arable agricultural production in China. We propose to use the stochastic meta-directional distance function by incorporating agricultural emissions as a bad output. A province-level panel data covering 31 provinces of China for ten consecutive years (2011–2020), with a total of 310 observations is used. This paper expects to compare the estimated sustainable efficiency scores, examine regional variations of sustainable efficiency across China, reveal the relationship between desirable and undesirable output, identify social-economic factors (e.g., governmental expenditure on agricultural production, R&D, disaster agricultural land size, education of farmers, off-farm income etc.) for improving the sustainable efficiency of arable agricultural production. Results are informative for policy makers to outline advisory ways to achieve a sustainable and efficient farming sector by improving farmers' technology, reducing negative environmental impacts, and increasing farmers' welfare.

ABSTRACT Nº: [13] - DEALING WITH ENDOGENEITY IN RISK ANALYSIS IN THE STOCHASTIC FRONTIER APPROACH: A SCOPING REVIEW

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Benchmarking is crucial for policymakers to foster both the economic and environmental sustainability of farming. Despite the significant role of risk in agricultural production decisions, most studies on farm-level benchmarking analysis do not account for it. Moreover, when included, endogeneity issues are often not considered, which could over or understate the effect of inputs on output. Producers may modify input use in response to observed shocks resulting in a correlation between inputs and statistical error. In addition, endogeneity may arise when including the risk management tools. The presence of endogeneity leads to erroneous inferences about the estimates of input elasticities, economies of scale, and inaccurate estimates of technical efficiency.

Therefore, we reviewed the literature on farm productivity and efficiency, focusing on studies that have included risk within the stochastic frontier analysis (SFA). The main contribution of this review relates to the indication of a literature gap in terms of studies accounting for endogeneity and the clarification of methods used to account for it by using a risk-accommodating SFA.

Despite the increasing methods proposed in the literature to deal with endogeneity, only a few studies have treated it in farm risk-performance evaluations when using the SFA. Among them, 7 considered endogeneity bias resulting from self-selection due to the adoption of risk management tools, while 2 considered endogeneity associated with the input relation with observed shocks. We found a literature gap about a comprehensive approach development capable of dealing with endogeneity when assessing farm performance and risk. Neglecting endogeneity in these analyses leads to biased estimates and thus distorted policy recommendations.

ABSTRACT Nº: [93] - THE ESTIMATION OF ENVIRONMENTAL EFFICIENCY BASED ON METHANE EMISSIONS IN LIVESTOCK PRODUCTION

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Livestock rearing for milk production is a thriving economic activity in the rural-urban interface of Bengaluru district, India. Its prominence is the result of rapid and intensive urbanization of the region. Intensive use of concentrate feed for cattle has been observed by milk producers in the rural, peri-urban, and urban areas of this region. With the use of data of from a panel of milk producers, we measure methane emissions from cattle as a bad output from an environmental perspective. The measurement of methane emissions is based on feed ration and the cows' weight. Having extrapolated the methane emissions, we estimate environmental efficiency from two paradigms: 1) the undesirable output perspective, and 2) the material balance perspective. Finally, we compare the results of these two approaches and propose policies

which are expected to moderate methane emissions at the producer level for promoting sustainability in livestock production.

W1-2 EDUCATION I

Chair: Kathy Hayes

ABSTRACT Nº: [136] - OPTIMAL SCALE AND SIZE OF NORWEGIAN HIGHER EDUCATIONAL INSTITUTIONS

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Abstract: The aim of this paper is to investigate how optimal size for Norwegian higher educational institutions (HEI) have developed over a 10 year period starting at 2004. Following Frisch (1965) optimal scale is defined as scale elasticity equal to one. To compute scale elasticity, we use a parametric deterministic method proposed by Aigner and Chu (1968) and compute an output-oriented distance function based on the translog functional form. To go from optimal scale to optimal size is far from trivial in a multi-input/multi-output framework. To get some information about size we the look at the input and output vectors of those HEIs that have a scale elasticity close to unity. Our result reveals that the optimal size in terms of undergraduate study points has decreased over time and the optimal size of research has increased over time. We believe that the observed development is clearly linked to more overall emphasis on the research output of a university. In the Scandinavian countries and during the studied period, many HEIs put significantly more attention on research. Also, different quality assurance systems came in use. One such was the Norwegian system of ranking research outlets that made it possible to compare research outputs between HEIs regardless of the subject field.

ABSTRACT Nº: [50] - MEASURING EFFICIENCY OF PERUVIAN UNIVERSITIES: A STOCHASTIC FRONTIER ANALYSIS

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Estimation of the one sided error component in stochastic frontier models may erroneously attribute firm characteristics to inefficiency if heterogeneity is unaccounted for. In this work, we capture it through exogenous variables which may affect the location, scale, or both parameters of a truncated normal inefficiency distribution. The study has as aim to measure efficiency of Peruvian universities via stochastic frontier analysis (SFA). The dataset is a panel of thirsty five Peruvian universities observed in the period 2011-2018. In the stochastic frontier, we have considered the number of students that ended the BA, the number of professors, the budget etc, letting for the inefficiency component the research activity measured by the number of

papers published annually per professor, the region where the university is located and the ratio between executed and received budget. Our findings suggest that the inclusion of exogenous variables in the inefficiency distribution is able to capture university heterogeneity and helps to obtain more reliable efficiency scores and rankings.

ABSTRACT Nº: [303] - IS YOUR SCHOOL REALLY BETTER THAN MINE? AN INNOVATIVE PROPOSAL TO PERFORM SCHOOL EFFICIENCY EVALUATION.

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School efficiency evaluation is increasingly needed to provide policy makers and school managers with evidence to learn from best practises and improve performance.

In this context, non-parametric techniques have become quite popular to assess school technical efficiency as they allow to deal with multiple-outputs, do not require information about input or output prices and do not assume any distributional form. Quite often student level data from national evaluations or international large-scale assessments are aggregated at the school level to perform the analysis, overlooking the heterogeneity across schools at the risk of unfair assessments.

In this paper, we propose an extension of the traditional DEA formulation to directly take into account the inputs and outputs distribution within each school, without resorting to common aggregate measures such as the average or the standard deviation. The suggested framework allows different specifications to model input and/or output composition and to capture heterogeneity across schools. For illustrative purposes, we apply our proposal to an extensive dataset of more than 600 schools in Spain, coming from the last wave of the international large-scale assessment of PISA 2018. This empirical application shows how this tool could support educational policy making assessment while considering the possibility of a heterogeneous working and learning environment. To model potentially different school input composition, we consider the distribution of the student socio-economic characteristics.

ABSTRACT Nº: [57] - THE ROLE OF POVERTY MEASURES IN ACHEVING EDUCATIONAL EQUITY THROUGH SCHOOL FINANCE REFORM

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In this paper, we estimate a series of stochastic frontier cost functions for elementary schools, using a short panel of Texas data that allows us to account for student characteristics, input prices, environmental factors and student outcomes. Texas currently uses information about the share of students participating into the Free and Reduced Price Lunch (FRL) program to determine compensatory funding to provide to schools. The FRL measure has been criticized as a relatively poor measure of need. We consider a new, recently developed, measure of poverty, the Spatially Interpolated Demographic and Economic (SIDE) measure, as a possible

complement or alternative to the FRL measure. SIDE uses the income of the neighborhood in which the school resides as the basis to assess need and poverty. We find that using both metrics highlights the additional costs associated with serving high poverty populations in high poverty locations, i.e., neighborhood locations matter.

W1-3 PRODUCTIVITY ANALYSIS I

Chair: Jose Manuel Cordero

ABSTRACT Nº: [210] - DIGITAL TECHNOLOGY AND TECHNICAL EFFICIENCY – HOW INTANGIBLES COMPLEMENT PRODUCTIVITY OF FIRMS

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The aim of this study is to analyse the relationship between digital tools and firm efficiency at the firm level across Sweden. Software development and big data analytics require certain resources and skills, and firms that invest in these advanced technologies are expected to be digitally sophisticated. However, does it make them more productive or efficient? We aim to show how these digital technologies determine firm efficiency using the data on Swedish firms. A Stochastic Frontier (SF) model is applied using cross-sectional data to estimate the production frontier and the technical inefficiency functions simultaneously. We draw on the firm-level register data collected in 2018 and the ICT survey from 2016. This time lag minimises the risk of reverse causation.

We find that the effect of digital technologies on firms' efficiency is not homogeneous across the economy. First, we provide evidence of firm-size gaps in the adoption of advanced digital tools. We estimate that large firms drive the adoption of big data and software development processes. Service and manufacturing large firms that integrate software development and big data analytics into their business models are closer to their own production frontier. Second, SMEs in manufacturing that develop business model software internally are more likely to improve their capabilities to optimize the production process.

ABSTRACT Nº: [73] - ASSESSING TECHNICAL PROGRESS, ENVIRONMENTAL CHANGE, AND TECHNICAL EFFICIENCY AT THE PROVINCIAL LEVEL IN VIETNAM DURING 2010-2019

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Vietnam´s economic growth has been remarkable over the last three decades, however, the fundamentals of development are still fragile. The growth drivers in Vietnam have been primarily dominated by the expanding labor force, capital deepening, and less on productivity growth. This article aims to provide further insight into technical progress, environmental change, and technical efficiency at the provincial level in Vietnam during 2010-2019 using

stochastic production frontier analysis. We further analyze the difference in productivity and efficiency in the study period to determine the impacts of the production environment, technology, and scale efficiency. The results show that productivity has increased in real terms by 3.6 percent per annum, on average, across all provinces over the period 2010–2019. The results also show that provincial competitive index (PCI) has a positive effect, while foreign direct investment (FDI) has a negative impact on production efficiency for the study period. It implies that better provincial institutions and FDI incentives are needed to improve productivity.

ABSTRACT Nº: [106]- IN-WORK INCOME STOCHASTIC FRONTIERS: METHODOLOGICAL ADVANCES FOR INEQUALITIES INVESTIGATIONS

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The existence of inequalities in income distribution is closely related to the standard conceptualization of efficiency. In this paper, the idea is to measure the differences between a potential in-work income, that should be obtained for an individual with particular socio-economic characteristics given his investment in human capital, and the actually received income. In detail, we estimate a similar Mincer equation for individual income, which incorporates human capital variables such as experience, education and occupation.

In studies related to stochastic earnings frontier, some scholars use the Stochastic Frontier (SF) approach to get efficiency of logarithms of wages and refer to traditionally approach employing Normally distributed error components. The implicit hypothesis of this specification is that wages follow a log-Normal distribution. However, in the literature it has been shown that the latter distribution is not suitable due to the poor ability to describe both the upper and lower tails of the observed incomes distribution. To overcome this problem, the starting point of our specification is to use the Dagum function, for which it has been shown that it fits very well to the income distribution.

To test the new SF specification, the paper uses individuals data from 9 longitudinal components of IT-SILC (Statistics on Income and Living Conditions for Italy). It collects timely and comparable cross-sectional and longitudinal data on income, poverty, social exclusion and living conditions and covers the period 2004-2015. This time span allows us to evaluate the impact of economic crisis to the difficulty of workers in achieving their potential income in different countries and regions. Moreover, the effect of welfare politics will be investigated.

ABSTRACT Nº: [192] - THE MEASUREMENT AND DECOMPOSITION OF PRODUCTIVITY CHANGE WITH ENVIRONMENTAL VARIABLES: A CONDITIONAL NONPARAMETRIC FRONTIER ANALYSIS APPROACH

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Contextual variables usually play a main role in explaining relative efficiency differences in most empirical applications. Nevertheless, most studies focused on analyzing productivity changes over a period usually do not account for the influence of these variables, especially those adopting a nonparametric approach. In this paper, we propose a novel method to incorporate information about contextual variables in Malmquist productivity decompositions based on the conditional nonparametric efficiency measures. The usefulness of the proposed approach is illustrated in an empirical application using data about EU regions so that we can investigate the extent to which the quality of governance influenced the evolution of regional productivity in the years following the last financial crisis.

W1 -4 TRANSPORT II

Chair: Kenneth Løvold Rødseth

ABSTRACT Nº: [117] - BENCHMARKING OF RAIL CARGO CARRIERS IN ITALY

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Efficiency in the railway industry has been a topic of interest in the last decades. Recent policy developments at the European level make the issue even more important. Indeed, according the objectives of the Green Deal, rail´s share of the transport market needs to be increased due to the favourable environmental records. The current European Commission legislative agenda, among other proposals, is focused on making freight transport more sustainable overall, as outlined in the recently adopted Sustainable and Smart Mobility Strategy. This means that rail freight operators' efficiency is expected to play an increasingly relevant role in the next future of the European transport industry. In this regard, the paper aims at measuring the technical efficiency of rail freight operators in Italy in the period 2016-2018 and at identifying some of its determinants. To the best of our knowledge no previous paper applies benchmarking techniques to operators of the Italian railway industry. Furthermore, the evidence specifically on rail carriers (especially cargo carriers) seems a bit limited given also the limited data availability.

We build a data set of the main rail cargo carriers operating in Italy. We then identify the key (i) input, (ii) output, and (iii) "environmental" variables looking also at the existing literature (e.g., Oum et al., 1999; Cowie, 2007; Jitsuzumi and Nakamura, 2010; Feng and Zhou, 2010; Merkert et al., 2010). According to our definition of production process, cargo train operators transform labor and capital into train-km (or ton-km). Their technical efficiency can be influenced by the level of competition, the vertical integration, and some other aspects (e.g., network characteristics and nationality). Efficiency is finally estimated through a non-parametric approach based on Data Envelopment Analysis (DEA). More specifically, our estimation plan is as follows. First, we check for the presence of outliers through data cloud method (Wilson 2008). Second, we apply DEA to obtain biased-corrected efficiency scores. Third, following Simar and Wilson (2007), we combine bootstrap and truncated regression to investigate the impact of the environmental variables on the obtained scores.

Our analysis leads to a ranking of the rail cargo carriers operating in Italy and also provides some evidence on the factors affecting the performance in the industry. We expect to find significant differences among operators on the basis of their characteristics and to be able to derive some indications for policy makers in the light of the recent policy developments at the EU level.

ABSTRACT Nº: [165] - NETWORK SFA: EFFICIENCY OF MULTI-STAGE PRODUCTION PROCESS WITH APPLICATION TO TRANSPORT

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Overall efficiency is commonly used as an indicator to assess performance of firms. However, it does not provide insight into what causes efficiency which is of greater interest to scholars and policy makers. To address this issue, serval scholars attempt to exploit the multi-stage characteristic of production processes to distinguish efficiency between stages. The first stage produces intermediate outputs which are used to produce final outputs in the second stage.

Compared to a one-stage approach, the multi-stage approach offers great benefits (although it might face challenges in computation). First, by explicitly considering the production stages overall efficiency can be decomposed into stage efficiency to have better understanding of how inefficiency arises. Second, the approach is expected to yield more reliable prediction of efficiency since it avoids biases of a failure to capture the presence of intermediate outputs in production.

With these advantages, several multi-stage DEAs such as separate DEA and network DEA have been developed. However, this development in SFA seems to be missing. To the best of the authors' knowledge, only Huang et al. (2017, 2018) sought to form an economic model equivalent to network DEA. Nevertheless, they focused on stage-efficiency and seemed to ignore overall efficiency.

Our paper thus further develops the network SFA model to estimate overall efficiency by explicitly formulating the relationship between overall and stage efficiency. Departing from Huang's paper we do not focus on shared inputs nor employ a two-step estimation procedure. Instead, we will adopt a one-step procedure of Lai and Huang (2013) to estimate copula-based SFA. To demonstrate the applicability our model will be applied to evaluate efficiency in transport.

ABSTRACT Nº: [67] - COMPUTING THE MARGINAL SAFETY BOUNDARY IN SOCIO-TECHNICAL SYSTEMS

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Safety performance in Socio-Technical Systems (STSs) has become a primary focus in many sectors due to its dynamic characteristic and the complexity of human-machine interactions.

This study aims to develop a quantitative risk assessment model of STSs based on Jens Rasmussen´s well-known theoretical accident framework (1997). The framework suggests that driving forces push STSs to ´´flirt with the margin´´ and thus prompt the system to operate in a high-risk environment, ultimately leading to catastrophic system failures, i.e., accidents. In this study, we propose a systematic and rigorous approach to quantify the safety margin of STSs. First, we form a conceptual model based on theory; then, we transform the conceptual model into a quantitative model by utilizing a performance assessment method- Data Envelopment Analysis. By calculating the marginal safety boundary location, the model can assess the system´s risk level and prevent accidents. The result also supports the ´´Migration of the Safety Boundary´´ contention by utilizing real-world data of a typical STS - the Belgian Railway Traffic Control Center.

ABSTRACT Nº: [181] - TRANSPORT EFFECTIVENESS DURING COVID-19: LOCALLY WEIGHTED STONED ANALYSIS OF E-SCOOTER PROVIDERS IN OSLO

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Benchmarking of transport providers is instrumental in strengthening the competitiveness of alternatives to car transport. In this context, efficiency measures the relationship among inputs and outputs, while effectiveness concerns the relationship among inputs or outputs and transport demand.

This study pioneers in effectiveness measurement of e-scooter providers. It applies Stochastic Nonparametric Envelopment of Data (StoNED) to measure effectiveness, which is advantageous both because it accommodates a non-parametric technology in combination with a composite error term and because the technology and impacts of contextual variables can be jointly estimated.

The standard approach to modeling contextual variables in StoNED is to assume they influence production in a Hicks-neutral way. This may not be an appropriate assumption when considering effectiveness of e-scooter providers, where the demand is uncertain and fluctuates strongly subject to weather conditions and other external factors such as gasoline prices. We discuss and implement extensions of the StoNED approach to accommodate non-separable contextual variables.

E-scooters were introduced in Oslo, Norway, in 2019, which has since seen a rapid growth both in demand and number of providers. At the same time, the transport sector has been dramatically changed due to the outbreak of Covid-19. A main objective of this research is to analyze how Covid-19 has influenced effectiveness of e-scooter providers. We analyze treatment effects by exploiting structural changes in governmental and municipal Covid regulations in the context of a Regression Discontinuity Design founded on locally weighted StoNED. A unique panel on e-scooter mobility in Oslo and its neighboring city Drammen is used for the assessment.

W1-6 SPECIAL SESSION - NEOCLASSICAL PRODUCTION ECONOMICS AND FOUNDATIONS OF EFFICIENCY ANALYSIS

Chair: Subal Kumbhakar, State University of New York, US, & University of Stavanger, Norway

W2-1 AGRICULTURE VI

Chair: Gabriel Rosero

ABSTRACT Nº: [171] - AGRICULTURAL PRODUCTIVITY AND CLIMATIC EFFECTS: A PRELIMINARY OVERVIEW OF MODEL SPECIFICATION IN ECONOMETRIC STUDIES

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There is a growing literature that uses econometric methods to evaluate the impact of climatic effects on agricultural productivity. The climatic variables incorporated in these models have been defined in several different ways but the effects that different variable definitions have on findings related to productivity is unclear. We intend to ascertain the extent to which alternative specifications in studies that use panel data affect the results and associated implications.

We scanned the relevant literature to identify studies that focus on estimating the impact of climatic effects on agricultural production using statistical tools. Our search yielded 69 papers employing panel data used to estimate a total of 276 different regressions. The literature reveals that different approaches have been used with respect to the type of data used, the definition of the outcome variable, the level of aggregation, the control variables included, the models and functional forms and, most interestingly, the variety of climatic variables employed. For climatic variables, most studies use some measure of both temperature and rainfall. Several studies use alternative measures and the most frequently used proxy for temperature is degree days. Other variables used often are relative humidity, wind speed, sun exposure, excess heat degree days, temperature or heat indices, and dummy variables for extreme weather events.

Ongoing work is focusing on defining ordinal response variables that will characterize the type of climatic response reported in the studies (e.g., negative, none, positive). These response variables will then be used as dependent variables in meta ordinal logistic regression models where the regressors will be key attributes of the studies.

ABSTRACT Nº: [233] - ESTIMATING OUTPUT-SPECIFIC INPUT QUANTITIES FROM AGGREGATE FIRM-LEVEL DATA

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Most firms produce multiple outputs, while input quantities in firm-level data sets are usually aggregated to the firm level and the proportions of the input quantities that are used for producing each of the outputs are unknown. However, several analyses require data on the input quantities for each produced output, particularly analyses used for policy making and business decisions. We assess various approaches for estimating output-specific input quantities and so-called input allocation coefficients that have been proposed in the literature. We distinguish between four econometric methods: (1) classical econometric methods, (2) random coefficient regression, (3) entropy-based methods, and (4) Bayesian econometrics. Classical econometric methods usually give unreliable and implausible results because they are based on economic and statistical assumptions that are not fulfilled in typical firm-level data sets. Random coefficient regression has the advantage that it relaxes the unrealistic assumption of classical econometric methods that all firm have the same input-output coefficients. Entropy-based and Bayesian approaches can incorporate prior knowledge and, thus, usually give more reliable results. However, existing applications with entropy-based or Bayesian approaches have the same drawback as classical econometric methods: they require the unrealistic assumption that all firms have the same input-output coefficients. Therefore, we propose to estimate input allocation by combining random coefficient regression with Bayesian approaches. We assess the suitability of this approach for real-world analyses by applying it to a representative data set of Danish farms and conducting the estimation with the Hamiltonian Markov Chain Monte Carlo method.

ABSTRACT Nº: [28] - OPTIMAL TIMING OF NITROGEN USE: AN INTEGRATED NETWORK TECHNOLOGY APPROACH

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Nitrogen (N) runoff from agricultural production remains a leading contributor to global water quality impairment. Reducing N pollution in the face of rising food demands will require more efficient N fertilizer use, taking into account both the quantity and timing of application, as well as the spatial heterogeneity of production technologies and environmental factors determining N runoff into surrounding waterways. We address each of these dimensions, by drawing on productivity theory to model the crop production technology at different stages of the crop growing cycle. We integrate this dynamic production model with a biophysical model to track the plant and soil uptake of N at each stage, along with unwanted N loss in the form of water pollution. We apply this integrated productivity-biophysical framework to wheat production in New South Wales, Australia for the 2015 and 2017 growing seasons. We find a greater potential for N pollution reduction by employing dynamic optimization of N use under our framework, relative to the more common single-stage joint production approach which only considers the overall level of N use. We also find that by not accounting for the timing of soil and plant N uptake at each stage, single-stage production models may over-state the potential to increase crop yields while also decreasing N pollution.

ABSTRACT Nº: [227] - SEMIPARAMETRIC STOCHASTIC FRONTIER ANALYSIS ACCOUNTING FOR SPATIAL DEPENDENCY. A COUNTRYWIDE ANALYSIS OF ECUADORIAN COCOA PRODUCERS

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Although chocolate is a $130 billion global industry, most cocoa farmers are located below the poverty line. Improving the productivity and efficiency of cocoa farms may constitute an important tool to enhance rural incomes and contribute to poverty reduction. With repeated cross-sectional data (2017-19), we estimate a comprehensive, country-wide analysis of the productivity and technical efficiency cocoa sector determinants in Ecuador. This paper seeks to overcome certain drawbacks of the standard SFA, such as a strong parameterization of the production function and omitted variable bias due to spatial dependency. Thus, we introduce a semiparametric SFA that adopts a generalized additive model (GAM) in a spatial framework that models a flexible production function, estimates the exogenous factors´ effect on efficiency in a one-step procedure, and accounts for territorial differences using an intrinsic autoregressive model. We find that cocoa producers operate under decreasing returns of scale, the advanced age of the harvested cocoa trees, the most relevant adverse effects on production. Our estimates show that premium cocoa farmers are 57% less productive. However, the average efficiency of cocoa producers is 79%, so producers could increase their productivity levels by addressing their inefficient sources. The main drivers that decrease inefficiency are using better irrigation systems, applying soil analysis, and having a female household head. We also find that cocoa productivity and technical efficiency depend on the farm´s location. Therefore, policies aiming to improve productivity and efficiency in the Ecuadorian cocoa sector must invest in tree rejuvenation, address the low productivity of premium varieties, and consider spatial effects.

W2-2 - EDUCATION II

Chair: Audrone Jakaitiene

ABSTRACT Nº: [84] - APPROXIMATIONS AND INFERENCE FOR NONPARAMETRIC PRODUCTION FRONTIERS: NEW DEVELOPMENTS

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Nonparametric methods have been widely used for assessing the performances of organizations in the private and public sector. The most popular ones are based on envelopment estimators, like the FDH or DEA estimators, that estimate the attainable sets and its efficient boundary by enveloping the cloud of observed units in the appropriate inputs-outputs space. The statistical properties of these flexible estimators have been established. However these nonparametric techniques do not allow to make sensitivity analysis of the production outputs to some particular inputs, or to infer about elasticities and other coefficients

of economic interest. On the contrary, parametric models for production frontiers allow richer and easier economic interpretation but at a cost of restrictive assumptions on the data generating process. In addition, the latter rely mostly on regression methods fitting the center of the cloud of observed points. In this paper we offer a way to avoid these drawbacks and provide approximations of these coefficients of economic interest by "smoothing" the popular nonparametric estimators of the frontiers. Our approach allows to handle fully multivariate cases. We describe the statistical properties for both the full and the partial (robust) frontiers. We consider parametric but also flexible approximations based on local linear tools providing local estimates of all the desired partial derivatives. An illustration on real data from European Higher Education Institutions (HEI) shows the usefulness of the proposed approach.

ABSTRACT Nº: [131] - ASSESSING POLICY IMPACTS ON MEXICAN STATE UNIVERSITIES' PRODUCTIVITY: A DIRECT AND INDIRECT (BUDGET CONSTRAINED) APPROACH

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Nowadays, pursuing a higher education degree is considered an universal right in egalitarian societies. However, markets on their own are unable to provide an efficient amount of this educational service, therefore, public funding and governmental assistance are necessary to compensate for the market failures (Wigger and von Weizsäcker, 2001).

Public funding in higher education is present in almost all countries in the world, as it is considered a social good as it creates Intellectual Capital (Shultz, 1956,1971), (Mincer, 1962), (Becker, 1964,1993,1994), which is an important determinant to foster economic growth (Romer,1990), (Arrow, 1997), (Hanushek, 2010); to generate social mobility (Haveman and Smeeding, 2006); and to produce well-being (Cuñado y Pérez de Gracia, 2012),(Yakovlev and Leguizamon, 2012), (Rojas, 2020).

In recent years, the public pressures and competition for resources for several programs, is forcing Governments to provide better accountability, to optimize taxpayer-generated resources and to improve its efficiency (Clark, 1983). Mexico is not the exception to be exposed to public pressures, as it provides important funding to support the public higher education system which is growing at annual rates of 4% and accounts for two thirds of the total of 4.6 million enrolled students.

Despite the efficiency and improvement of Mexican HEIs has been previously studied by authors such as Güemes-Castorena (2001), Sagarra, Mar-Molinero and Rodríguez-Regordosa (2014), and Sagarra, Mar-Molinero and Agasisti (2017); this study is valuable since it collected data for the 34 Public State HEIs for a long period of time (28 years from 1989 to 2017) and therefore long term effects of policy implementations can be obtained. This study is also original because the annual budget and prices of inputs were obtained and indirect (budget constrained) technology can be computed (using DEA) and then combined with direct technology to calculate efficiency, and to build a combined (direct/indirect) geometric Malmquist index to assess productivity gain and to run its further decomposition in four sub-indexes: (1) direct technical efficiency change; (2) direct scale efficiency change; (3) allocative

efficiency change and (4) indirect frontier shift for each HEIs and for the system as a whole. It is also original as it uses the GAIN function (as described by Grosskopf et al., 1999), for the first time in higher education, to compute the additional efficiency that could be achieved by HEIs by allocating resources in a more efficient way without spending more budget.

Our findings for the 28 year study period are that the Mexican State HEIs have been able to produce important productivity gains in the indirect frontier shift, very slight gains in direct technical efficiency change and direct scale efficiency change, and productivity losses in allocative efficiency change. We were able to find the best and worst performers for each sub-index and to realize that there is still an important gap for productivity that could be gained by HEIS using the same budgets but changing the mix of inputs that would maximize outputs. We explain the factors that may have been productivity triggers such as performance based budget and enrolment growth; and productivity laggers such as the power of unions and rigid labor laws. Our study can be useful for both public policy makers to design funding policies better aligned to produce productivity gain, to mitigate unproductive union interactions, and to promote more flexible labor laws; and for HEIs administrators to observe best performers and to emulate the best practices such as hiring and tenure track policies, that actually trigger productivity and allow them to get closer to the frontier and eventually to push the frontier outwards.

ABSTRACT Nº: [59] - MODELS OF MULTICOMPONENT TECHNOLOGIES WITH RESTRICTIONS ON THE ALLOCATION OF SHARED INPUTS AND OUTPUTS

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We consider the scenario in which the production technology can be viewed as a combination of several (parallel) production processes. As an example, in the context of higher education, a university may be viewed as a combination of two or three processes: science, non-science and, often, medical departments, each having different practices and cost structures. Alternatively, in the same context, we may consider universities involved in the two component processes: research and teaching. Similar examples can be found in many other contexts, including school education, hospitals, transport, banking and agriculture. In the general setting, each process is characterized by a dedicated component-specific set of inputs and outputs. We also assume that there are shared inputs and outputs, the allocation of which to individual component processes is unknown. In the university context, examples include central administration costs and the number of papers published by the authors affiliated with the university. The multicomponent VRS and CRS technologies recently developed for this setting allow independent convex combinations of component processes of the decision making units. These models also combine shared inputs and outputs. Because the allocation of shared inputs and outputs is unknown, these models combine them assuming the worst-case scenario that is mathematically possible taking into account all possible allocations. To develop these models further, we additionally assume that there are certain lower and upper bounds on the proportion of the shared inputs and outputs that can be associated with each process. An example is the judgement that each component process uses at least 5% of the shared inputs and does not produce more than 90% of the shared outputs. Theoretically, such information reduces uncertainty about the unknown allocation of shared measures to component

processes, improves the worst-case scenario used for the evaluation of shared inputs and outputs, and results in a larger model of technology. We show how the additional lower and upper bounds can be incorporated in the original multicomponent models. We also provide an empirical illustration and demonstrate the usefulness of the proposed models in the context of higher education.

ABSTRACT Nº: [75] - THE ASSESSMENT OF PERFORMANCE TRENDS AND CONVERGENCE IN EDUCATION AND TRAINING SYSTEMS OF EUROPEAN COUNTRIES

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The Strategic Framework for European Cooperation in Education and Training (ET 2020) aimed to promote the exchange of best practices among the Member States. This paper assesses the performance evolution of European countries in terms of the common objectives for the education sector. The framework used to evaluate European education systems is based on constructing a composite indicator adopting a ``benefit-of-the-doubt´´ approach. The evaluation of performance change over time is done using a global circular Malmquist index. Sigma and beta convergence of EU countries are also explored using non-parametric frontier techniques. The results are analysed for the period 2009-2018 and discussed in light of the goals envisaged and the national policies adopted. The results revealed a trend of improvement in the performance of education systems in most European countries in the period analysed. Although most European countries moved closer to the European best practice frontier over time, as confirmed by the values of sigma-convergence, a few countries are still lagging considerably below their peers, as revealed by the existence of divergence in beta.

W2-3 PRODUCTIVITY ANALYSIS II

Chair: Paul W. Wilson

ABSTRACT Nº: [47] - REGIONAL VARIATION IN TOTAL FACTOR PRODUCTIVITY IN THE SWEDISH TOURISM SECTOR

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Even though the tourism sector gets a lot of attention it is a fact that it does not exist in official statistics. The national statistics of the tourism sector is constructed from parts of different sectors based on, for example, the World Tourism Satellite Account framework (TSA). In this study we are trying out one method for regionalizing tourist statistics in order to measure productivity development on municipality level. Previous research on regional tourism productivity mostly relays on proxies for the tourism sector or by treating each region as replica

of the country. For example, in Barros & Alves (2004), Barros (2005), Chen and Soo (2007) and Peypoch & Sbai (2011) the tourism sector is approximated by the hotel industry. In Peypoch (2007) and Peypoch & Solonandrasana (2008) stayovers in hotels and at camping facilities represents the tourism sector. Another stream of literature identifies all sector that, on some criteria, are related to tourism production and perform their analysis on each sector separate (see e.g. Li et al., 2016), not taking into account that some sectors might be more or less depended on tourism. There are a few studies that have a regional dimension. Cracolici et al. (2007) studies productivity differences between regions in Italy and Sun et al. (2015) studies productivity differences in Chinese provinces are two exceptions.

There are at least two of problems to be resolved. Firstly, the sectors that make up the tourism sector are differently dependent on tourism. Approximate the tourism sector by one or several industries do not take this sector heterogeneity into consideration. Secondly, there is regional heterogeneity relating to tourism dependency within a sector.

We are approaching these shortcomings in two steps: In step one we use the Swedish TSA survey data to get the share of tourism per sector on average. To get a measure tourism importance for a municipality we use over nights stays data and create weights. By combining these two steps we 'create' a municipality specific tourism sector. To compute total factor productivity, we use a Malmquist index approach. The result is in the range of 0.70-1.35.

ABSTRACT Nº: [238] - SOLICITING THE WISDOM OF THE CROWD FOR COMPARING TOTAL FACTOR PRODUCTIVITY

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Total factor productivity (TFP) compares aggregate output quantity to aggregate input quantity. It is an essential measure for benchmarking economic performance of decision-making units (DMUs).

Aggregation requires assigning weights to each quantity of input and output. In empirical TFP measures, market prices define these weights. In theoretical TFP measures, aggregations are estimated by distance functions, which boils down to assigning shadow prices to the weights.

TFP can be compared over time and across space, which necessitates at least some fixity of weights. There is a consensus on choosing fixed weights in bitemporal and bilateral comparison. Since both DMUs could be eligible for choosing the weights, it is reasonable to choose the average weight among the two DMUs.

The degree of fixity of weights is contested more when comparing three or more DMUs. One may restrict weight fixity to two DMUs. Here, one characterises the weights close to the market condition in each DMU. Fisher and Hicks-Moorsteen indices are well-known examples. However, these TFP measures are intransitive: direct comparison of the TFP of two DMUs does not equal to indirect comparison through a third DMU. Transitive TFP measures such as Lowe and Färe-Primont indices fix the weights among all DMUs. However, the choice of these fixed weights may not be representative for the potentially very different market conditions.

This paper proposes a Wisdom-of-the-Crowd approach to TFP measurement, which averages the weights among all DMUs. The derived TFP measures are transitive, yet still incorporate the different market conditions among all DMUs considered. We illustrate our approach by an international comparison of country-level TFP using the publicly available Penn tables.

ABSTRACT Nº: [51] - STATISTICAL INFERENCE FOR AGGREGATION OF MALMQUIST PRODUCTIVITY INDICES

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The Malmquist Productivity Index (MPI) has gained popularity amongst studies on the dynamic change of productivity of decision-making units (DMUs). In practice, this index is frequently reported at aggregate levels (e.g., public and private firms) in the form of simple equally-weighted arithmetic or geometric means of individual MPIs. A number of studies have emphasized that it is necessary to account for the relative importance of individual DMUs in the aggregations of indices in general and of MPI in particular. While more suitable aggregations of MPIs have been introduced in the literature, their statistical properties have not been revealed yet, preventing applied researchers from making essential statistical inferences such as confidence intervals and hypothesis testing. In this paper, we will fill this gap by developing a full asymptotic theory for an appealing aggregation of MPIs. On the basis of this, meaningful statistical inferences are proposed, their finite-sample performances are verified via extensive Monte Carlo experiments, and the importance of the proposed theoretical developments is illustrated with an empirical application to real data.

ABSTRACT Nº: [81] - CONICAL HULL ESTIMATORS OF GENERAL TECHNOLOGIES, WITH APPLICATIONS TO RETURNS TO SCALE AND MALMQUIST PRODUCTIVITY INDICES

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Nonparametric models of production have been widely used for assessing the performance and efficiency of firms. Typically envelopment estimators are used to estimate the attainable sets and its efficient boundary.

Recent works from Kneip et al. (2015, Econometric Theory) provide the basic asymptotic tools for doing inference based on averages of FDH or DEA efficiency scores. The latter includes in Kneip et al. (2016, Journal of Business and Economic Statistics) a procedure for testing the hypothesis of constant returns to scale. Properties of DEA-type estimators of distance to the conical hull of convex production sets is then derived in Kneip et al. (2020, Econometric Theory), allowing to make inference on productivity changes measured by Malmquist indices.

So far these results impose the assumption of convexity of the attainable set. In many situation this convexity assumption is questionable. This paper extends the previous results for possibly non-convex technologies.

This implies to derive the properties of FDH-type estimator of the distance to the conical hull of possibly non convex attainable set. This produces also a FDH-type estimator of the boundary under constant returns to scale assumption. Then it is possible to extend the tools for doing inference on Malmquist indices to the case of possibly non convex technologies.

W2-4 BANKING I

Chair: Ana Lozano-Vivas

ABSTRACT Nº: [109] - INTERMEDIATION EFFICIENCY OF BANKS: A TAX EXAMPLE

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Traditionally, bank efficiency papers have focused almost exclusively on cost and profit efficiency. For many public policy purposes, this is of little use. We model the intermediation role of banks in matching lenders and borrowers. Our model allows us to estimate inefficiency in the intermediary role of banks. Identification is established through the inclusion of a special bank tax that is more or less randomly levied on some banks, and not on others. We estimate the model using data on Japanese banks, where the so-called Tokyo bank tax allows us to execute our identification strategy. We find that the tax indeed lowers the funding ability of the affected banks. The size of the effect depends on the existing dead weight loss in the intermediation process. The tax indeed increases inefficiency in the intermediation process for those affected.

ABSTRACT Nº: [114] - MEASURING BANKING PERFORMANCE IN A NETWORK DEA CONTEXT: A GENERAL WEIGHT ASSURANCE REGION MODEL

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This paper adopts the General Weight Assurance Region (GWAR) model of Kourtzidis et al. (2020) to the case of banking institutions with a two-stage network structure. The proposed model can handle multiple input, output and intermediate variables at both stages, including leakage variables in the first stage and inputs that enter the system in the second stage. The general structure of the model gives greater flexibility to the weights assigned to the two stages relative to the Weight Assurance Region (WAR) and the conventional additive network DEA model. Consequently, the weights of the GWAR model are not strictly non-increasing but they can take any possible value in the range of 0 to 1. As a result, they do not suffer from the criticism of Ang and Chen (2016). Furthermore, the GWAR model can be considered as the general case of all additive network DEA models. Regarding the modelling of banking efficiency, the network structure preserves the dual role of deposits by treating them as an intermediate variable, thus providing a solution to the deposits' dilemma. Finally, incorporating non-performing loans is essential to our suggested solution for the GWAR weights.

ABSTRACT Nº: [149] - BANKS' EFFICIENCY DECOMPOSITION, ENGAGEMENT IN SECURITIZATION AND PRODUCTIVITY GAINS

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Although the term shadow banking system usually refers to financial intermediation that occurs outside the banking system, banks found new ways to expand their profits and increase their efficiency with such activities, fostering the growth of this system. Some of the roots of this codependency are in the originate-to-distribute (OTD) model, and credit assignments by banks are a prominent example of this practice: financial institutions reduce the retention of originated loans, and nonbank financial intermediaries step in, acquiring credit pools and distributing them to investors with different risk appetites. In this sense, the shadow banking system depends on the banks themselves to perform many essential credit intermediation functions, thus becoming a parallel or ´´shadow´´ of the banking system. Some studies argue that bank regulation influences this dynamic because poorly capitalized banks are those that depend on the collection of fees for credit assignment activities to remain in business. Additionally, commercial banks´ use of shadow banking has significant impacts on their operational efficiency.

Using quarterly financial statements and credit assignment data from June 2001 to December 2012, the purpose of this study is to analyze the relationship between the use of shadow banking instruments by Brazilian banks (loan sales) and their efficiency, offering insights into the relationship between shadow banking and financial stability using a two-stage approach. We first model the bank production process via two joint technologies where loans are intermediate factors while explicitly considering a given level of credit risk. Indeed, each of the two technologies is linked to a specific activity and generates a specific type of revenue: operating income for the first technology and interest income for the second one. Moreover, the latter sub-process uses the distribution of total loans between performing and non-performing loans as an indicator of the bank´s credit risk profile. This value-based approach enables us to aggregate the two components of income efficiency into a global efficiency measure. Compared to other estimation strategies, using a non-parametric activity model such as data envelopment analysis (DEA) allows us to estimate the total bank efficiency score and its two components without relying on parametric assumptions.

On a broader basis, the decomposition of efficiency through two different sub-technologies before analyzing the decision to engage in securitization transactions most accurately resembles the decision-making process in a financial institution. Thus, secondly, we apply a TOBIT model on an unbalanced panel data to investigate whether bank efficiency is associated with the income from securitization transactions among other exogenous balance sheet indicators and control variables.

Our findings demonstrate that banks that securitize and sell originated loans are more efficient than those that do not. Moreover, income from securitization transactions is positively associated with interest income efficiency but not with operational efficiency. In contrast to international evidence but in line with studies that analyze the Brazilian securitization market, we also demonstrate that smaller banks (in terms of asset size) are those that rely more on securitization transactions. Finally, disentangling those effects when analyzing the decision to securitize allows a deeper understanding of the reliance on the originate-to-distribute model.

ABSTRACT Nº: [76] - THE EFFECTS OF TARP AND PPP PROGRAMS ON PERFORMANCE OF US BANKS. EVIDENCE FROM A FLEXIBLE STOCHASTIC FRONTIER MODEL

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We analyze banks' abilities to achieve a viable performance in the market. Given that banks' performance is subject to uncertainty since risk-taking is an inherent condition of the banking business, a clear understanding of what the underlying causes of a poor performance of banks, and to what extent these are transient or permanent over time, it can help regulators make a quick judgment about the likely effectiveness of available alternative tools. Regarding the important role that risk-taking has on bank business, we present a new framework to analyze the effect of risk-taking on bank performance (measured by a state-of-the-art stochastic frontier model). The banks´ risk-taking is analyzed by controlling for the possible incentives that government interventions aimed at ensuring banking stability during crises may have generated for it. In particular, by monitoring how government interventions thought the Troubled Asset Relief Program (TARP) and the Paycheck Protection Program (PPP) affect bank risk-taking.

Our method links the risk-taking to performance by considering firm heterogeneity, and transient and a persistent inefficiency. This new framework gives the possibility of having exhaustive information on how banks perform since it allows a wide variety of cases where (i) some banks are fully efficient (i.e., both persistent and transient inefficiencies are zero); (ii) some banks have only persistent inefficiency, (iii) while others have only transient inefficiency; (iv) and finally some banks have both transient and persistent inefficiency. Since we do not know in what category or categories a bank belongs, we estimate the probability of belonging to one of 4 distinct groups. Our general model allows most flexibility. First, the technology in each of the 4 groups can be different. Second, the proposed model allows probabilities of belonging to one of 4 groups to depend on covariates. The model is applied to a sample of US commercial banks, for which we assess cost efficiency for the period 2004-2020. The model is found to accurately distinguish heterogeneous performance responses to changes in risk exposures among banks, suggesting that regulators and government interventions need be aware not only of the consequences of prudential regulation and the public support on bank performance, but also of the different effects that polices intended to discourage risk exposure have on banks with different characteristics. They may be discouraging banks' abilities to achieve a viable performance in the market.

W2 -5 DEA METHODS III

Chair: Jesus T. Pastor

ABSTRACT Nº: [36] - BENCHMARKING ECONOMIC EFFICIENCY.JL: ECONOMIC EFFICIENCY MEASUREMENT WITH DATA ENVELOPMENT ANALYSIS

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Benchmarking Economic Efficiency .jl is a new package for the Julia language that includes functions for the measurement and decomposition of the economic efficiency of organizations. The software closely follows the book of the same title: Benchmarking Economic Efficiency: Technical and Allocative Fundamentals by Aparicio, Pastor and Zofío, forthcoming in Springer. It is publicly available for free from its dedicated website: https://benchmarkingeconomicefficiency.com/.

The package aims at a wide range of scholars and professionals working in the fields of economics, engineering, management science and operations research. Using Data Envelopment Analysis, the package includes code to decompose profit, profitability, cost and revenue efficiency, defined as ratios or differences. Depending on the functional form of economic efficiency it can be decomposed, either multiplicative or additively, into two separate and mutually exclusive components representing technical (production) efficiency and allocative (market) efficiency. The former can be measured through a number of DEA efficiency models.

The package implements traditional decompositions based on the radial (input or output) technical efficiency measures, and new ones based on the generalized distance function, the directional distance function, DDF (including novel extensions like the modified DDF, reverse DDF, or generalizations based on Hölder norms), the Russell measures, additive measures like the weighted additive distance function or the slack based measure, etc. This paper describes the methodology and implementation of the functions, and reports numerical results using a common dataset on financial institutions.

ABSTRACT Nº: [105] - PERMUTATION TESTS ON RETURNS TO SCALE AND COMPARISONS OF PRODUCTION FRONTIERS IN NONPARAMETRIC MODELS

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When benchmarking production units by non-parametric methods like data envelopment analysis (DEA), initially an assumption has to be made about the returns to scale characteristics of the underlying technology. Having decided upon a technology, researchers often subsequently aim to compare multiple frontiers across independent samples of producers. Here we introduce and assess permutation tests - usable also when only relatively small samples sizes are obtainable. Permutation techniques, where one recompute the test statistic over permutations of data, have a long history in statistics and have become increasingly useful as the availability of computational power has increased. Until now, no permutation tests for examining returns to scale assumptions in DEA, nor for test of equality of efficient frontiers, have been available.

In this paper, we develop three novel tests based on various permutations of the observations. We show that our suggested permutations satisfy the necessary randomisation assumptions, and hereby prove that the sizes of the proposed tests are controlled. The first of the proposed tests is a test for the hypothesis of constant returns to scale. The other two are, respectively, tests for general frontier differences and for whether the production possibility sets are, in fact,

nested. All tests are easily implementable from the algorithms provided in the paper. The advantages of permutation tests are that they are reliable even for relatively small samples and their size can be controlled. Additionally, weight restrictions can be added without additional computational difficulties. We furthermore demonstrate, both theoretically and by a simulation study, that the test is consistent under an asymptotic scenario with increasing sample size.

ABSTRACT Nº: [172] - POTENTIAL GAINS FROM MERGERS: DECOMPOSITION OF THE COST-BASED HARMONY EFFECT

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The model of potential gains from mergers based on Bogetoft and Wang (2005) provides a useful decomposition into the scale and the harmony effect. While the scale is well-elaborated, the deeper elaboration of the harmony effect remained open.

The aim of our paper is to provide insights into the impact of the harmony effect. In order to capture the effect for merger results in the cases of multiple inputs and outputs, we use Data Envelopment Analysis approach. For the input-oriented model, we can explain the harmony effect´s positive (non-negative) contribution to the overall merger effect. In the case of merging DMUs with the same peer group the harmony effect is equal one. Merging DMUs with the different reference set, the harmony effect is greater than one. For the case of two inputs, the effect is higher; the greater is the difference of the input multipliers for the merging DMUs. The economic interpretation lies in the diminishing marginal rate of input substitution.

In the second part of the paper, the analysis is extended by taking into account the given unit prices of inputs, which are different among DMUs. Based on the ´´new´´ cost efficiency and the decomposition procedure proposed by Tone and Tsutsui (2007) the potential gains from the harmony effect can be expressed as the sum (or product) of the (increasing) technical, price and allocative efficiencies. The analysis is extended by using the new joint unit prices of inputs for the merged unit, and by comparison with the previous model, the ´´pure´´ price and cost effects can be estimated. In this way, new insights into gains from the cost-based harmony effect – compared to the technical-physical based harmony effect can be revealed.

ABSTRACT Nº: [132] -THE STANDARD REVERSE APPROACH FOR DECOMPOSING ECONOMIC INEFFICIENCY

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As is well known, the traditional decomposition of economic inefficiency, which is always a non-negative quantity expressed in monetary units, is applied to a finite and homogeneous set of firms that compete in the same market, requiring knowledge of the corresponding market prices as well as the selection of a measure of technical inefficiency that determines the

projection of each firm. Focusing our attention on the additive profit inefficiency decomposition, two non-negative summands are identified for each firm. The first of these, known as its technical profit inefficiency, is the product of its technical inefficiency times a given normalization factor. This first addend is always less than or equal to the profit inefficiency of the firm, so the second addend is obtained as a residual, known as the allocative profit inefficiency. However, in real-life situations, firms and organizations are interested in benchmarking themselves against competitors representing the largest feasible profit improvement given market prices. Focusing on maximizing technical profit inefficiency or, equivalently, minimizing allocative profit inefficiency, constitutes the so-called reversed approach in the literature. We adopt this approach to introduce a new standard decomposition of profit inefficiency that is based on simple equalities and takes advantage of the usual relationship between each firm and its frontier projection. We further develop a new technical inefficiency measure that fits the requirements of the reverse approach. We also present a normalized version of the reversed decomposition that is units' invariant through the definition of a suitable normalization factor. In contrast to the traditional approach, the new decomposition complies with the properties of comparability and essentiality that the traditional decompositions fail to satisfy. These findings are easily extended to cost and revenue inefficiency decompositions.

W2-6 WATER REGULATION I

Chair: Rui Cunha Marques

ABSTRACT Nº: [212] - ASSESSING THE IMPACT OF PLANT LEVEL SCALE ECONOMIES AND LOCAL OPERATING CHARACTERISTICS ON THE COST OF SEWAGE TREATMENT

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A considerable number of academic and regulatory studies model the costs of water and sewage services at the company level and consider factors such as average population density in the served area as a determinant of input requirements and hence efficient costs. However, with very limited exception, the previous literature has effectively assumed that such companies are single system operators, when in reality they often operate multiple physically separate and distinct treatment, collection, and distribution systems, Moreover, within and between such companies local operating characteristics can vary significantly, thereby influencing not only system level performance but also aggregated company performance. Thus, if we wish to provide more accurate models of company level costs, it is necessary to better understand local system cost determinants.

In England and Wales, over 6000 sewage treatment plants are in operation but regulated prices for sewage services are currently set by Ofwat, using cost assessment models that assess sewage treatment operating costs at the company level, while also imposing a constant elasticity of scale across all companies. This paper will instead develop robust plant level analysis of the determinants of sewage treatment costs allowing for plant level variable scale economies. The models will further allow for local geographic and treatment plant characteristics including numerical constraints imposed by the environmental regulator on

treated effluent. The paper will therefore not only provide a robust plant level econometric benchmarking analysis of sewage treatment costs but will also inform future research aiming to account for disaggregated system characteristics into models of company level performance.

ABSTRACT Nº: [201] - EFFICIENCY ASSESSMENT OF WATER COMPANIES TO SUPPORT THE DESIGN OF ASSET MANAGEMENT POLICIES IN THE WATER SECTOR

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This research assesses the performance of Portuguese water companies operating at the bulk level. Special attention is dedicated to asset management practices, based on the indicators collected by the Portuguese regulator. The results obtained using a Benefit of the Doubt model are explored in terms of managerial insights, especially in terms of strengths and weaknesses of companies, as well as the peers and targets they should observe to improve efficiency. This study will provide innovative ways of using the information collected by the Portuguese regulator (ERSAR) to gain better insights on companies performance trends and promote improvements in the sector.

ABSTRACT Nº: [134] - REGULATORY EFFICIENCY OF WATER SUPPLY AND SANITATION REGULATORY AGENCIES IN BRAZIL

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Regulation of the water supply and sanitation (WSS) sector is important to protect the interests of both users and service providers, and to promote the quality of the WSS services provided. Thus, the efficient performance of the subnational regulatory agencies, which regulate and monitor WSS services in Brazil, should be guaranteed and promoted.

This study developed an assessment of the current scenario of regulation of WSS services in Brazil, including an analysis of the regulatory efficiency of subnational regulatory agencies. To analyze the efficiency of 53 subnational regulatory agencies, it was collected data regarding four main topics on the regulation of WSS services, namely: the characterization of the regulatory agency; the regulatory substance; the regulatory governance; and the quality of regulation. In sum, through the application of DEA it was found that most subnational regulatory agencies need to improve, more or less significantly, their regulatory efficiency.

This study is relevant not only for the WSS sector in Brazil, but also in other countries, since it provides a replicable framework to evaluate the regulatory efficiency of WSS regulatory agencies.

ABSTRACT Nº: [87] - EFFICIENT TARIFFS PAID FOR WASTEWATER SERVICES IN PORTUGAL

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The definition of tariffs in public services, including utilities, has been considered a flawed process, lacking some empirical and econometric support. Although theoretically, such a definition would intend to safeguard the financial sustainability of payers, it is not clear that the found solutions are Pareto-optimal. This means that the allocation of money may not be efficient. Additionally, quality and environment are two groups of dimensions of utmost importance, but they are usually disregarded from the tariff computation. First, the (exogeneous, non-discretionary) operational conditions impact on performance and, hence, on the capacity of being more efficient. Second, a provider can be more efficient because of the quality lowering. Therefore, these two classes of dimensions must be part of the wastewater tariff definition. In this study, we propose an alternative to optimizing tariffs paid by the wastewater provision using the frontier concept and the best practices within. Frontiers are assessed using an appropriate function based on the well-known Data Envelopment Analysis, augmented by the capacity of providing unique solutions. To ensure that both quality and environment are considered in the frontier assessment, we use the concept of conditionality, such that the reference set where inefficient water providers are projected contains only those observations operating under similar conditions and delivering better services.

W3-1 AGRICULTURE VII

Chair: K Hervé Dakpo

ABSTRACT Nº: [236] - THE POTENTIAL IMPACT OF FINANCIAL CONSTRAINTS ON DYNAMIC FARM PRODUCTION DECISIONS: AN APPLICATION TO DUTCH DAIRY FARMS

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Insufficient access to finances is a prevalent problem in the agricultural sector. This affects farmers' production and investment decisions, and ultimately decreases profit in the long run. The objective of our research is to provide insights into the implications of the current provision of agricultural financial services by developing an approach to quantify financial constraints and their corresponding long-term opportunity cost. Past studies focused on the short-term opportunity costs from financial constraints on buying variable inputs using a static approach, not considering long-term opportunity cost from financial constraints on investments and the associated adjustment costs. They used a stated or revealed approach to determine the financial constraints, not considering farmers' ability to take out loans to make larger investments. We combine data on actual expenditure and on financial performance to judge creditworthiness esteemed by finance institutions. We compute the dynamic financial efficiency as measure of the opportunity cost by extending the static model proposed by Färe, Grosskopf and Lee to the dynamic context. Using a nonparametric framework, we apply our approach to 264 specialized Dutch dairy farms for the years 2006-2017 and explore the

potential impact of changes in finance provision for several scenarios. The main contributions lie in the assessment of farm businesses' creditworthiness, the extension to the dynamic context to account for adjustment costs and the creation of multiple scenarios to inform policy. Our preliminary findings reveal that 5-32% of farm businesses during the time period experienced financial constraints. The approach reveals the accessibility of finances and which farms should be targeted to improve access to finance.

ABSTRACT Nº: [112] - THE POTENTIAL OF CIRCULARITY TO DECOUPLE GREENHOUSE GAS EMISSIONS FROM PRODUCTION: AN APPLICATION TO THE DUTCH DAIRY SECTOR

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The Dutch agricultural sector is facing many interrelated environmental and economic challenges. The currently dominating policy issue is the reduction of the ammonia emissions. Another challenge, namely climate change is not less serious, although it is less characterized by today's political urgency (Jongeneel & Gonzalez-Martinez, 2021). The Dutch government has developed its national Climate Agreement in order to comply with the Paris Agreement on climate. Key to the current policy on the Dutch agriculture is the vision to create a circular agriculture. The key principles include closing cycles by optimizing resource-efficiency, the cycling of resources and waste, the reduction of external inputs like artificial fertilizers, pesticides and fossil fuels, continuous systemic improvements and cross value chain collaboration, as well as lowering possible emissions and negative externalities.

This study aims to explore the efficiency gains that could be gained from a circular system by reallocating land between livestock production and crop production on the same dairy farm using Data Envelopment Analysis (DEA).This study combines the directional distance function with the by-production model of Murty, Russell, and Levkoff (2012), and extends on the previous work of Ang and Kerstens (2016). Directional distance function helps to find various improvement directions not limited to radial contraction to or expansion from the origin. Additionally, on modelling pollution-generating technologies, by-production modelling (Murty et al., 2012) based on the estimation of multiple frontier technologies is the current most promising method due to its strong theoretical background (Dakpo, Jeanneaux, & Latruffe, 2016).

In this study, two sub-technologies are operationalized as intended-production technologies for livestock production and crop production, and a third residual-production technology is for greenhouse gas emission. The empirical application focuses on representative Dutch (mixed) dairy farms over the period of 2010 to 2019. On average, there are 190 farms for each year. The data is from the Dutch Farm Accountancy Data Network and we distinguished technology specific inputs and outputs sets. For the crop production technology, we have crop specific costs, upcycled manure, crop land use, crop yields, and the crop outputs used for animal feed. For the livestock specific technology, we have livestock units, livestock specific costs, feed from own crop production, grassland for livestock land use, livestock production, and total manure from farm; and there are joint shared inputs for both the crop production technology and the livestock production technology. For the greenhouse technology, we have included only the pollution generating inputs and the total on-farm GHG emissions. We aggregated the monetary

inputs and outputs as implicit quantities by computing the ratio of their aggregated value to their corresponding aggregated Törnqvist price index. The separate price indices are obtained from Eurostat database and the Dutch CBS database.

Our preliminary results suggest that by re-allocating more land (an average of 4,7 acreage) to crop production on a Dutch dairy farm (66 acreage on average), farms can simultaneously increase production and reduce GHG emissions. This indicates that the circularity principle holds: by becoming less specialized, Dutch dairy farms are able to have economic and environmental gains. The average technical inefficiency score without land reallocation is 4.48%, and the coordination efficiency gain will be on average 0.6% for each farm. The results from this study also confirm with the previous findings by Ang and Kerstens (2016) that coordination inefficient dairy farms should in general allocate more land to crop production. Future research will investigate the potential to increase production and reduce GHG emissions separately.

ABSTRACT Nº: [195] - IS COST EFFICIENCY DETERMINANT ON DAIRY PRODUCTION FOR AN EXPORT-ORIENTED COUNTRY?

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Uruguay is a small market with a large export-oriented agribusiness sector. That imposes a challenge for being competitive on the international markets. One of the sectors that is most affected by the international competition is dairy production. Its main export products are commodities making it contingent on international prices. Over the years the dairy systems have shifted from an extensive grass-fed model into more intensive farming combining cultivated pastures and larger amounts of high-quality feed. Production saw a maximum in 2013 and a decline since 2014. There are previous works on TE of dairy farms but no on input misallocation and the corresponding allocation inefficiency. The objective of this paper is to estimate dairy farms performance, considering TI and AI. This study uses an unbalanced panel of 82 dairy farms along a maximum of 12 agricultural years (2005/06 to 2016/17) with a total of 853 observations. Using stochastic frontier approach, a production function and first-order conditions for cost minimization system is estimated for TI and AI. One output, total milk produced, and three inputs: number of cows; concentrated feed; and total land. Four alternative models were specified. Our results indicate that input misallocation, using total number of cows as numeraire, are low use of concentrated feed and overuse of land. This is consistent with the agronomic recommended practices of increasing the stocking and feed intake. TE for the four models ranges between 73 and 92.5%. When persistent TE is separated from residual effects it shows a score of 77% indicating that management is key. Improving TE, cost can be reduced between 7.5 to 33% depending on the model. By correcting input misallocation, the cost can be reduced between 35 and 55%.

ABSTRACT Nº: [228] - MULTI-LEVEL HETEROGENEITY AND EFFICIENCY OF FRENCH WINE PRODUCERS: A NESTED LATENT CLASS APPROACH

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The global wine market is changing rapidly with the emergence of new actors. To keep their leading position, French wine producers must be competitive and meet the increasing consumer demand for healthy and quality products. One of the critical challenges is the zero to minimal use of chemical inputs such as pesticides and mineral fertilizers and favoring polyculture systems. These challenges raised the questions of French wine producers´ efficiency and the heterogeneity in their practices. While the former is highly related to competitiveness, the latter embedded production technology characterization to shed some light on the previous challenge. To answer these questions, we analyze a large sample of French wine producers from 2002 to 2020. The sample covers all French areas, even though a large proportion of the farmers are located in the Bordeaux region. Moreover, we consider the nested latent class stochastic frontier model, which combines the virtues of zero inefficiency and latent class stochastic frontier models. The zero inefficiency stochastic frontier model allows some of the observations to be fully efficient while others are inefficient. The latent class stochastic frontier model splits the sample into groups of observations depending on their production technology. Overall, the observations are divided into four nested groups in our case study. We distinguished between intensive and extensive wine producers classes, and within each of these classes, the observations are also split into efficient and inefficient groups.

W3-2 EDUCATION III

Chair Gabriela Sicilia

ABSTRACT Nº: [15] - ALTERNATIVE SOURCES OF FUNDING AND ITS EFFECTS ON EDUCATIONAL EFFICIENCY: IMPACT CAUSAL OF AULA GLOBAL PROGRAM IN PERFORMANCE

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Education is a priority mainly because of the externalities it presents in terms of well-being (McMahon, 2004; Wolfe & Haveman, 2002), labour productivity (Mankiw et al., 1992) and economic development (Hanushek & Woessmann, 2008). Globally, it is at the center of the 2030 Sustainable Development Goals (SDG) agenda, where a commitment is made to "guarantee inclusive, equitable and quality education and promote lifelong learning opportunities for all" (PNUD & UNESCO, 2015). Educational efficiency is a subject of intense political, social and academic debate (De Witte & López-Torres, 2017), and in recent years, concern has grown due to the increase in educational costs (Eurostat, 2014) and the high private financing in developing countries (Aksoy, 2015), so it is important to ensure that educational spending is carried out with a high level of efficiency and that it has a positive effect on improving quality.

In general, the responsibility for spending on education lies with the government (Rahman & Uddin, 2009), however, private organizations have increased their contributions mainly in developing countries (Aksoy, 2015), therefore, understanding this type of Initiatives is essential

for economic and social development (Gibson & Davies, 2008). The SDGs involve companies to achieve development in a faster way (Rosati & Faria, 2019), for example, the United Nations Global Compact report, highlights that 51% of companies participate in projects with public associations or private (United Nations, 2018). However, in many of these initiatives, agreements on evaluation metrics and data collection are challenging (Rosati & Faria, 2019) and the evidence for the evaluation of results is scarce (United Nations, 2018, p. 19).

The objective of this study is to evaluate the causal impact of the "Aula Global" program on school efficiency, through an innovative procedure (De Witte & Smet, 2018) where literature on the evaluation of social policies is combined (Abadie & Cattaneo, 2018) and efficiency (Simar et al., 2016). Following the approach of De Witte and Smet (2018), this study assesses for the first time the causal impact on educational efficiency of a program (Aula Global) financed by private organizations. In addition, it should be noted that the impact evaluation is carried out taking into account multiple outputs and inputs, something that is not considered in the policy or program evaluation literature. Additionally, unlike the previous study, endogeneity is treated with a "Randomized controlled trial design" approach and not through "Regression discontinuity design".

The empirical application of this study is carried out by evaluating the effects of the Carvajal Foundation´s "Aula Global" program on the educational efficiency of 6455 students in 25 schools in Cali, Colombia. Specifically, the impact of tutoring for students with academic lag in primary education in disadvantaged socioeconomic contexts is evaluated. Different programs are carried out around the world with the aim of closing socioeconomic gaps and increasing educational quality because the socioeconomic level of students is recognized as one of the main determinants of their results (Agasisti et al., 2018; Thieme et al., 2013).

The main results of the present study are twofold. First, the Aula Global program presents a positive effect on the efficiency of students who are lagging behind, with a difference between the control and treatment groups of up to 9.6%. And second, the program has a greater magnitude in its effect in lower academic grades (second and third). On the other hand, the main contribution is the type of empirical application, where social policy and efficiency methodologies are mixed. Additionally, literature requests are addressed where evidence is required on the effect of private contributions on educational quality.

ABSTRACT Nº: [63] - LANGUAGE AS A STRATEGIC CHOICE — DRAWING GLOBAL RESEARCH TALENT BY SWITCHING TO ENGLISH

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We show, using a difference-in-difference (DiD) identification, that introducing English as the official language of instruction in a degree program increases the existing citation count of new faculty hires in Dutch and Belgian universities. These results are robust to a battery of controls including university and time fixed effects as well as university specific time trends. We argue that switching to English reduces labor mobility barriers, allowing universities in non-English speaking countries to recruit from the global talent pool.

ABSTRACT Nº: [162] - EFFICIENCY AND EFFECTIVENESS FROM THE PERSPECTIVE OF INCLUSION AND FAIRNESS: ANALYSIS OF THE EU EDUCATION SYSTEMS

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Inclusive and equitable quality education is at the top of the agenda of education authorities worldwide. However, frontier-based efficiency studies involving cross-country comparisons of education systems in terms of educational equity are still incipient. This paper elaborates on the concepts of efficiency and effectiveness from the perspective of inclusion and fairness to propose a conceptual framework for education systems. According to the proposed framework, the education system of a country could be optimal, selective, excessive, or deprived. We used the framework for 26 European countries to illustrate its applicability. The Data Envelopment Analysis approach based on a directional distance function model with both desirable and undesirable outputs was used to measure effectiveness and efficiency. The comparison amongst education systems are based on all key-stages of education: early childhood, primary, lower secondary and upper secondary, and tertiary education. The empirical results indicate that European countries do not follow the common policy framework for ensuring inclusion and fairness in their education systems as well as within the country between key-stages. Heterogeneity is observed not only between the education systems of the countries but also within the countries in Belgium, Cyprus, Czechia, Finland, France, Greece, Hungary, Romania, and Slovakia. In other EU countries, common features of education policy could be defined that encompass all stages of education in the country. We find the intermediate optimal-excessive option in several ISCED levels in Austria, Estonia, Italy, Latvia, the Netherlands, Poland, Portugal, Slovenia, Spain, and Sweden. The optimal-deprived model prevails at some educational levels in Bulgaria and Lithuania. We also observe the presence of intermediate selective-excessive options in Luxembourg and Malta.

ABSTRACT Nº: [60] - EDUCATIONAL EQUITY IN THE OECD COUNTRIES: A MULTIDIMENSIONAL ANALYSIS USING COMPOSITE INDICATORS

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In this research we provide a novel methodology to better understand one of the most relevant social challenges: the improvement of educational equity. Using a robust conditional Benefit of the Doubt (BoD) model we construct a composite indicator that compares the performance across countries in terms of educational systems equity based on a single criterion, without losing its multidimensional nature and respecting the different priorities and particularities of educational systems, which makes the comparison fairer between countries. To achieve this purpose, we first revisit and select the most appropriate individual indicators that allow capturing the different dimensions of educational equity. Subsequently, we aggregate them in sub-dimensions and finally, we compute a synthetic measure using the conditional BoD model, in order to account to the heterogeneous priorities and characteristics of the different

educational systems included in the analysis. The main attraction of this model is that it does not require establishing weights for the sub-indicators a priori, but rather they are determined endogenously. This, among other advantages, have made this method very popular in recent years in various areas such as competitiveness, the environment or well-being. However, it has never been applied to the measurement of educational equity, which makes this application innovative. In short, this research aims provides a tool that can be used not only to monitor the evolution of educational equity across OECD countries, but also to assess the impact that certain national policies may have on it, in order to contribute to its improvement and to the promote a culture of evidence-based public policy design.

W3-3 PRODUCTIVITY ANALYSIS III

Chair: Bert Balk

ABSTRACT Nº: [144] - A NEW APPROACH TO APPROXIMATE THE PRODUCTIVITY FUNCTION IN TERMS OF EFFICIENCY AND EFFECTIVENESS

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As a critical step in the growth and development of organizations, productivity refers to the optimal use of available resources and facilities to achieve organizations´ goals, visions, and policies. Therefore, policymakers and economists consider productivity an essential factor for society´s prosperity and economic growth. Productivity is usually considered to be the same as the concept of efficiency and effectiveness, while each has a different meaning. According to the definition, efficiency is ´´doing the things right,´´ effectiveness is described as ´´doing the right things,´´ and productivity is referred to as ´´doing the right task properly.´´

In general, productivity evaluation is done in two ways. Productivity assessment, through indicators such as Malmquist or Leuenberger, shows changes in productivity over time. On the other hand, productivity can be obtained through efficiency and effectiveness. There exist few studies to measure productivity through efficiency and effectiveness. This study introduces a new approach to estimate productivity as a function of efficiency and effectiveness and supposed that efficiency and effectiveness are two dimensions of productivity. An interpolation method was proposed in this study to evaluate the productivity of DMUs through efficiency and effectiveness simultaneously. This approach can discover appropriate productivity functions for estimating productivity values of DMUs and predicting them for the following years.

ABSTRACT Nº: [65] - THE MORE OF LESS: FIRMS' PRODUCTIVITY, WAGES AND SIZE.

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The aim of this paper is to test the relationship between firm's productivity, wage and size. Starting from the seminal contribution of Moore (1911), empirical studies based on 20th century data find the larger is the size of an establishment the higher is the worker's wage and productivity. However, the large-firm wage and productivity premium tend to disappear in the last 30 years (Bloom, Guvenen, Smith, Song and von Watcher, 2018). We test whether this conundrum can be explained by the Baumol and Bowen (1966)' theory on cost disease, which suggests that productivity in the service sector tends to grow slower than in the manufacturing ones. Furthermore, we study whether efficiency can contribute to this divergence. For doing this, we exploit the high-quality administrative register datasets collected by Statistics Denmark which has full coverage of the entire population living in Denmark during the period 1980-2013 with the possibility to match the employees to their correspondent firms' characteristics.

ABSTRACT Nº: [24] - GENETICALLY MODIFIED ORGANISMS AND AGRICULTURAL PRODUCTIVITY

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Using a newly available data set that covers 15 OECD countries for the sample period 1973-2011, we study the impact of adopting GMO techniques on aggregate agricultural productivity. Our results indicate that GMO adoption has no statistically significant impact on aggregate agricultural total factor productivity and decreases aggregate agricultural capital productivity relative to labor productivity.

ABSTRACT Nº: [300] - WHY IS THE COBB-DOUGLAS PRODUCTION FUNCTION SO POPULAR?

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It is well known that, in continuous time, the Cobb-Douglas function can be derived from the underlying, data governing, accounting identity under some reasonable assumptions (factor shares are constant, and the weighted growth of the labour input price and the capital input price is constant). In this paper these results are generalized in three ways: 1) the accounting identity contains a (pure) profit term; 2) continuous time is replaced by discrete time periods; 3) additional assumptions appear to be superfluous.

W3-4 BANKING II

Chair: Flávia Barbosa

ABSTRACT Nº: [9] - A NON-PARAMETRIC EVALUATION OF CAIXA´S SERVICE DYNAMICS FOR REFORMULATING QUEUES OF SOCIAL PROGRAMS

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The consequences of the current pandemic are externalized on many sectors of economic activity due to the need for physical contact during service provisions. The public banking services provided by the Brazilian Federal Savings Bank (Caixa Econômica Federal) have been critical in this context.

This research proposal aims at evaluating the service dynamics of Caixa reformulating the utilization factor for the service units into a non-parametric comparative perspective that can identify potential for improvements in terms of mean service rate for the most critical bank sectors (i.e. improvements in the expected number of customers completing service per unit time) and the best queue disciplines (the order in which clients are selected for service).

We estimate the expected queue length, waiting time in the queue and the expected number of arrivals per unit time based on the service time (output) and based on the number of servers (bank personnel and tellers), the number of clients per month (non-discretionary) and average waiting time per month (inputs). The results are promissory for supporting the bank branches to offer a minimally satisfactory service for customers, increase the business profitability and mitigate the effects of the pandemic within and outside units.

ABSTRACT Nº: [178] - BENCHMARKING LOAN BUSINESS IN THE DANISH BANKING SECTOR AFTER THE FINANCIAL CRISIS

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Denmark has been significantly affected by external factors including the international financial crisis in the late 2000s and the overheated domestic mortgage market. The paper attempts to analyze the status of the relative efficiency of individual banks' loan activities from 2011 to 2015 based on the data envelopment analysis (DEA) non-parametric approach. This study constructs a loan efficiency map that simultaneously measures the determinants of the relative loan efficiency of the banks under consideration. The loan efficiency of a bank was decomposed into two factors: lending efficiency (loan amount/deposits) and profitability (net interest income/loan amount). By using these parameters, a two-stage DEA model was applied to measure the relative distance of individual factors from the industry benchmark.

After mapping their DEA scores, banks can be classified into four groups based on their lending efficiency and profitability relative to the benchmark. Based on the DEA calculation and mapping results, two consolidation processes can be highlighted in the Danish banking industry. First, banks with the optimal loan efficiency in both lending and profitability acquired banks in order to improve their loan efficiency. In 2011/2012, both banks acquired banks with less efficiency in profitability but efficiency in lending to complement their weakness. Second, the banks that either discontinued or were merged had a potential risk in bank loan activities is not providing loans but profitability management.

ABSTRACT Nº: [239] - TESTING THE PREDICTIVE POWER OF NON-PARAMETRIC METHODS OF PERFORMANCE MEASUREMENT OVER MUTUAL FUNDS

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The objective of this paper is to investigate the superiority of one or several non-parametric performance measurement methods for predicting later performance of mutual funds over the past twenty years. The paper should use efficiency measurement from traditional mean-variance and multi-moment DEA models, diversification-consistent models, network DEA models or multi-criteria decision-making using DEA. Both convex and non-convex versions of the models should be used as well. Performance measures and the rankings they imply will then be compared with both the realized performance and rankings of the funds in the following years, both during non-crisis periods and covid-crisis periods.

ABSTRACT Nº: [115] - THE IMPACT OF THE SINGLE SUPERVISORY MECHANISM ON EUROZONE BANKING: THE ASSESSMENT OF TRENDS IN EFFICIENCY AND FRONTIER POSITION

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As a first step towards a Banking Union, the Single Supervisory Mechanism (SSM) was implemented in November 2014. It involved the transfer of supervisory power to the European level, with the European Central Bank becoming the central supervisor of financial institutions in the Eurozone. This paper investigates the impact of the SSM on Eurozone banks' efficiency and position of the best-practice frontier. It is based on a balanced panel analysis of 931 European bank-year observations over the period 2011-2017 (133 banks, seven years). The study was based on a difference-in-differences approach to explore the evolution of banking performance. Special attention was given to the specification of the dependent variables, in order to reflect efficiency changes as well as movements of the best-practice frontiers. We found that the SSM had a negative impact on the efficiency levels of Eurozone banks, particularly in the year after the introduction of the mechanism. Additionally, we observed that the frontier formed by non-Eurozone European Union banks is more productive than the frontier of Eurozone banks in all years analysed. Both efficiency and frontier position show evidence of a recovery trend in more recent years for both groups. We also found that while Equity-to-Asset Ratio, Return on Average Assets and Gross Domestic Product per capita had a positive impact on banks' efficiency, domestic credit provided by banks expressed as %GDP had a negative impact on efficiency.

W3-5 DEA METHODS IV

Chair: Walter Briec

ABSTRACT Nº: [147] - A FAIR COMPOSITION APPROACH IN NETWORK DATA ENVELOPMENT ANALYSIS

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Network Data Envelopment Analysis (NDEA) is an extension of Data Envelopment Analysis (DEA) that takes into consideration the internal structure of Decision Making Units (DMUs) in the efficiency assessment. Specifically, in NDEA, every DMU is conceived as a network of several sub-processes (stages, divisions) arranged into a series, parallel or mix of series and parallel structures. Therefore, in such structures, the divisional efficiency scores as well as the overall efficiency of the DMU have to be assessed. There are two broad classes of approaches in NDEA, i.e. the decomposition (top-down) and the composition (bottom-up) approach. In the former one, the overall efficiency of the DMU is optimized first and the divisional efficiency scores derive as offspring from the optimal solution. In the latter one, the divisional efficiency scores are assessed first and the overall efficiency derives ex-post. Notably, the methods that follow the composition approach rely on Multi-Objective Programming (MOP) techniques. Specifically, these methods treat the divisional efficiency scores as distinct objective functions and they differ in the scalarizing function they employ to locate a unique point on the Pareto Front of the objective functions space. However, selecting a point on the Pareto Front that secures the fairness among the divisions is of crucial importance, as it will allow to set a common basis for comparison of the divisional scores of each DMU as well as to derive the overall efficiency.

In this paper, we focus on two-stage series structures and we develop a fair composition approach to derive the divisional and the overall efficiency scores. Our modelling approach relies on MOP techniques, but contrary to the existing methods in the literature, we identify the divisional efficiency scores in a min-max and max-min sense simultaneously. Specifically, we identify a point on the Pareto Front that is as close as possible to the highest divisional efficiency scores (Ideal point) and as a far as possible from the lowest divisional efficiencies (Nadir point). Comparison with other prominent methods in the literature, highlights the differences and the advantages of our new method.

ABSTRACT Nº: [92] - PROPORTIONAL INCREMENTAL COST PROBABILITY FUNCTIONS AND THEIR FRONTIERS

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The econometric analysis of cost functions is based on the analysis of the conditional distribution of the cost Y given the level of the outputs X in R^p and given a set of environment variables Z in R^d. The model basically describes the conditional distribution of Y given X >= x and Z=z. In many applications, the dimension of Z is naturally large and a fully nonparametric specification of the model is limited by the curse of the dimensionality.

Most of the approaches so far are based on two-stage estimations when the frontier level does not depend on the value of Z.

But even in the case of separability of the frontier, the estimation procedure suffers from several problems, mainly due to the inherent bias of the estimated efficiency scores and the poor rates of convergence of the frontier estimates.

In this paper we suggest an alternative semi-parametric model which avoids the drawbacks of the two-stage methods. It is based on a class of model called the Proportional Incremental Cost Functions (PICF), adapted to our setup from the Cox proportional hazard models extensively used in survival analysis for durations models. We define the PICF model, then we examine its properties and propose a semi-parametric estimation. By this way of modeling, we avoid the first stage nonparametric estimation of the frontier and avoid the curse of dimensionality keeping the parametric √n rates of convergence for the parameters of interest. We are also able to derive √n-consistent estimator of the order-m robust frontiers (which, by contrast to the full frontier, may depend on Z) and we prove the Gaussian asymptotic properties of the resulting estimators of the m-frontiers. We illustrate the flexibility of the procedure by some simulated examples and with a real data application.

ABSTRACT Nº: [126] - ON THE REFERENCE TECHNOLOGY USED IN ESTIMATING EFFICIENCY APPLYING A NON-PARAMETRIC DEA APPROACH

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The point of departure of the paper is two statements by Michael James Farrell in his seminal 1957 article on efficiency measurement introducing his definitions of efficiency measures; technical efficiency, cost efficiency and overall efficiency: The method [proposed by Farrell] provides, as a sort of by-product, an estimate of the efficient production function, and he continues: It will not be surprising if the method of estimation is not the best for any particular use, for it was chosen simply as providing the best measure for technical efficiency. I will elaborate on what Farrell may have had in mind making these two statements, and also point to a problem missing in the literature when calculating efficiency in the case of vintages of capital exhibiting embodied technology.

The production concept in economics is rather limited as to complexity compared to engineering production functions. The standard approach in economics is to start with a production possibility set containing outputs and inputs and just saying that this set of outputs can be produced by a set of inputs. Typical inputs are capital, labour, energy and services abbreviated KLEMS. Outputs consists of the final marketed ones. To state that inputs are transformed to final outputs may not show the technology in an engineering sense. The economic production function is typically formulated on a much more aggregated level than

engineering functions. An engineering function or a blueprint of technology starting from "nuts and bolts" may involve a lot more inputs, intermediate outputs and several relationships than the typical economic production function. Farrell saw two options; using "a theoretical function specified by engineers, and an empirical function based on the best results observed in practice." He chose the last.

The engineering approach started with the seminal 1946 article by Hollis Chenery using the transport of gas in pipes had very few variables. Vernon L. Smith in his 1961 investment book had a chapter about transmitting electricity that also uses very few variables, underlining the fact that if engineering function are to be used by economists they have to be very simple.

Henry Tulkens and co-authors developed an approach that may be providing the best measure for technical efficiency; the free disposal hull (FDH). In the two-dimensional case it is rather obvious that the staircase shape of the frontier is far from the shape of a production function in an engineering sense. Tulkens (1993) claims that the strength of FDH is that "individual units are always rated in reference to another one, belonging to the frontier".This statement will be discussed.

In heavy industries – steel mills, pulp and paper, cement, electricity production etc.– real capital often have embodied technologies. This means that one should not assume that all machines can obtain the efficiency of the latest investment. Production possibilities for a firm are determined not by the latest investment, but of all existing pieces of capital. The efficiency frontier shifts over time due to investments and scrapping. Static efficiency based on the latest machines may be rather misleading giving a deceptive appearance of perpetual dissatisfaction with existing structure which has no basis in a dynamic perspective.

The concept of a technical production function in the service sector with a high share of labour as inputs – the public sector including ministries, hospitals, courts, teaching institutions, and financial institutions etc. – is not so relevant. Different types of organisation is more the case. However, this may fit in better with the economic types of a production function.

ABSTRACT Nº: [89] - DIRECTIONAL AND NORMED DISTANCE FUNCTIONS IN PREORDERED AND PARTIALLY ORDERED VECTOR SPACE

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This paper takes a new look at the problem of measuring technical efficiency using directional and normed distance functions. Specifically, the paper focuses on pre-ordered and partially ordered vector spaces by proposing a suitable encompassing netput formulation of the production set. Duality theorems extending some earlier results are established in the context of infinite dimensional spaces. The paper considers the directional and normed distance functions and analyzes their relations. Among other things, overall efficiency can be derived from technical efficiency under a suitable preordered vector space structure. More importantly, it is shown that the existence of core points in partially ordered vector spaces guarantees the comparison of production vectors using the directional distance function. Although the interior of the positive cone may be empty in vector spaces of infinite dimension, it is shown that

normed distance function can also be used to measure efficiency in such spaces by providing them with a pre-order structure.

W3-6 WATER REGULATION II

Chair: David Saal

ABSTRACT Nº: [152] - EVALUATING THE PERFORMANCE OF WASTEWATER TREATMENT FACILITIES IN LATAM

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Many Latin American countries face the increasing threat of water scarcity which will only be exacerbated by the ongoing climate crisis. Drought events are costly for the region resulting in annual GDPs between 0.6 and 1% below their potential. Considering that 65% of water used in LatAm is disposed without treatment, wastewater recovery and reuse facilities have an enormous potential to close the water stress gap in the region. Inadequate incentives and lack of investment in water infrastructure are drivers of poor economic performance.

There are several methodological approaches that can be used to analyze the performance of wastewater treatment facilities, but they are conditioned by the availability and quality of the data. In this study we will follow the non-parametric approach to assess the technical efficiency and that has been extensively used in the literature to assess the economic performance of wastewater treatment plants (WWTPs) from a production economics perspective.

By reframing wastewater treatment as a productive process, where the purified resource is suitable for reuse (agricultural, industrial, etc), the productive performance of the WWTPs can be analyzed by employing non-parametric techniques that would contribute to further interpret the structural and circumstantial limitations that condition the optimization of the operation and maintenance (O&M).

At the same time, by acknowledging the myriad characteristics that shape the performance assessment, this paper builds a performance analysis of 90 WWTPs in 5 Latin American countries and derives follow-up suggestions on technological innovation, management optimization and process improvements.

ABSTRACT Nº: [135] -NON-PARAMETRIC METHODOLOGIES ON THE REGULATION OF WATER SERVICES IN BRASÍLIA

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The promotion of incentives for efficiency and effectiveness should be a concern of the technical and economic regulation of water supply and sanitation services. With this concern

in mind, ADASA (water regulator of Federal District in Brazil) implemented a robust and complex regulation model, introducing non-parametric methodologies to assess the performance of regulated services, namely Data Envelopment Analysis (DEA) and Törnqvist Index (for TFP), in order introduce incentives in tariff setting (X Factor). The results achieved directly impact the definition of the tariff for the subsequent regulatory period. This work seeks to characterize the regulatory model of ADASA for water services, with particular relevance to the methodologies adopted for performance assessment and its regulatory impact of tariffs.

ABSTRACT Nº: [160] -THE CONSEQUENCES OF INDUSTRIAL RESTRUCTURING, REGIONAL DEVELOPMENT AND INSTITUTIONAL REFORM FOR PORTUGAL'S WATER SUPPLY SERVICE QUALITY IMPROVEMENTS: A MULTI-TIER META-FRONTIER DEA-BASED DECOMPOSITION

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The Portuguese government has taken measures to promote water supply services quality improvements, adjusting the industrial restructuring, regional balanced development, and institutional reform. Each of those dimensions may be construed as: different service bundling alternatives (vertical and horizontal integration), technology gaps between regions, and resource allocation efficiency. The aim of this paper is to assess the effects of this measures on water supply services quality improvements by using a newly proposed decomposition approach, which identified new factors related to the above measures, with a hierarchy defined meta-frontier. The analysis is centered in the by-production technology and distance function, sectoral and regional heterogeneity, and the decomposition model. Convexity and non-convexity assumptions were assessed. Constant and variable returns to scale (CRS & VRS) were also a setting condition, which are discussed additionally to convexity and non-convexity assumptions in the DEA models used.

ABSTRACT Nº: [196] - MEASURING THE POWER OF REGULATION IN THE ENGLAND AND WALES WATER AND SEWERAGE INDUSTRY

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The ultimate goal of economic regulation is to limit the market power of regulated companies. However, assessing the effectiveness of regulation in achieving its objectives is especially tricky in a multi-product context. Market power is usually measured with the Lerner index or the mark-up of the firm concerned. In practice, obtaining estimates of these measures is problematic. Firstly, information on output and input prices, necessary to calculate marginal costs and the Lerner index, is often missing, incomplete and/or unreliable. Secondly, there are difficulties related to differences between firms in the quality of services provided. Thirdly, the estimation of a flexible multi-product cost function presents multicollinearity problems associated with the use of squared and cross-product terms. The first and the third problems can be avoided by

using the cost share equations using the input distance function. The second problem is mitigated by controlling for the cost implications of quality improvements in the model.

In England and Wales, water and sewerage companies (WaSCs) are privately-owned regulated monopolies. Since the industry was privatized in 1989, its price cap based regulatory framework has had the dual goals of improving the quality of service, while also providing consumers with fair prices. This paper analyzes the performance of this regulation between 1990 and 2015. To do so, we apply a stochastic frontier model to estimate market power. Specifically, we estimate mark-ups for water and sewage for each company, while accounting for the quality of service provided. Moreover, we analyze a number of variables that further explain mark-ups over the period considered, and also examine whether mark-ups have declined after each quinquennial price review.