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Frontier Production Function and Cost Efficiency Empirical Analysis of Bioenergy Industry in EU28 Region

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Abstract: Over the last few years concerns have enhanced about the bioenergy industry as main source for renewable and sustainable energy in many countries. These concerns have been major magnitude for countries with joint green energy legislation such as European Union (EU28) countries. A significant aspect to be considered when selecting a provided bioenergy is the efficiency involved in its production. In this context, the current study analyzes the cost efficiency components in bioenergy industry in EU28 between 1990 and 2013. To this end, parametric and non-parametric frontier models are applied where both are particularly appropriate in this special context due to their treatment of undesirable outputs. Results are presenting equal means for cost efficiency in developing and developed countries. Allocative efficiency in developing countries is higher in compare with the one developed countries. While technical efficiency mean presenting higher value in developed countries in compare with developing ones.

Key word: Bioenergy industry, technical efficiency, EU28 region, energy, source

INTRODUCTION

Applied bioenergycost efficiency will boost to provide benefits that are of strategic importance to EU28 bioenergy industry, including economic growth, energy security, environmental quality and technology leadership. To obtain these valuable benefits, EU28 members are working in partnership in high level (e.g., industry, academia and the national laboratories) toidentify the keys drivers of bioenergy industry development to enhance sustainable bioenergy production, lowering the technical and economic risks.Bioenergy industry is part of many EU28 Region strategies to reduce climate change impacts and structure a diverse and secure localrenewable and sustainable energy supply. EU28 bioenergy industry help to minimize dependence on imports, make efficienttrade balance, settle down fuel prices, revive rural communities, make new jobs, keep the lead in science and innovation, improve the green energy security and mitigate carbon emissions. To obtain high technical and economic benefits in bioenergy industry, the EU28 boosts the sustainable development and conversion ofbiomass resources into advanced bioenergy (such as renewable, gasoline, diesel and jet fuel). In bioenergy industry, biofuel can be the only renewable substitute for petroleum-based liquid transportation fuels available in the short term.The estimated available biomass from different sources in EU28 can be forest resources, agricultural resources, energy crops and waste streams. EU28 region needs to enhance yields and produce biomass of consistently high quality, economical and reliable manner to achieve large scale production with competitive low cost in compare with other energy sources.

In 2010, National Renewable Energy Action Plan (NREAP) schedule gives detailed road maps of how the European Union (EU) countries can reach the 2020 targets, which can be summarized as follow: 20% mitigation of Greenhouse Gas (GHG) emission in comparing with 1990 emission level, 20% increment of the portion of energy production from renewable energy sources, 20% reduction of energy consumption from conventional sources through increasing the efficiency. Scowcroft and Nies have indicated that bioenergy is a significant player to reach the 2020 (NREAP) targets.Hereby, the studyconcentrate on the significance role of cost efficiency of bioenergy industry to face the challenges related to biomass feedstockshortage, increasing biomass imports, increasing biomass prices, environmental and climate change impacts which can be implemented through the investing in higher and modern inputs (such as capital, labor, raw material,

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technology, etc.) to provide higher cost efficiency and produce competitive bioenergy outputs in energy markets.

Where in 2009, around (1.7 million tonnes) were imported to EU Region from different Regions among the world, by 2012, imported biomass has increased to (4.6 million tonnes) by 2020 EU region biomass imports are anticipated to reach (15-30 million tonnes). Also, employing higher cost efficiency methodin bioenergy industry can achieve more economical output and increase the productivity by 40% in compare with inefficient employed methods. Moreover, cost efficiency can contribute to reduce CO_2 by 22% among the world by 2035.

In EU region, bioenergy production (from wood pellets) has enhanced by more than 30% over the period between 2009 and 2012. However, some EU members state (such as Denmark, Finland, Italy and Sweden) have hardly touched the limits or even reduced the bioenergy production in worse scenarios due to unavailability of biomass feed stock. However, this reduction has happened due to many reasons; the shortage of biomass raw material (wood pellet) supply, high cost of bioenergy production and high competition with biomass imported countries (Tromborg *et al*., 2013),

Bode and Groscurth (2006) have pointed that the total electricity production from bioenergy (and renewable energy sources) have increased from (1 billion euros) to (4 billion euros) and the increment will keep rising to reach the (9 billion euros) during the period between 2000 and 2011. Bode and Groscurth have indicated that the total cost of electricity production (Feed-in approach) from biomass (and other renewable sources) has increased significantly during the period starting from 2000, 2007 to 2011 by approximately (1 ME) Million Euro, (10 ME) Million Euro, to reach the amount of (20 ME) Million Euro, respectively

According to Tromborg *et al*. (2013), biomass feedstock cost estimated around 60% of the total production cost (for example bio-wood production), while the enhancement by 11 and 32% in biomass costs can be reflected on the bio-wood production (wood pellet) cost by 7% and 20% respectively. Serious enhancement in biomassprice could lower the profitability and production of bioenergy from forest sources (Tromborg *et al*. 2013).

Welfle *et al*. (2014) have presented the biomass potential resource availability (biomass growth resource, biomass residue resource and biomass waste resource) during the period from 2015-2050 years in the EU region. The statistics shows that biomass growth resource range during the period between 2015 and 2050 will be around (2.5 million tonnes) to (31 million tonnes), respectively while biomass residue resource during the period between 2015 and 2050 anticipated to be around (12.5 million tonnes) to (30 million tonnes), respectively. On the other hand, biomass waste resource during the period between 2015 and 2050 has predicted to be around (15 million tonnes) to (90 million tonnes), respectively, since biomass feedstock is considering the main input in bioenergy production and consume around 60% of bioenergy total production cost, the above figures indicated to the importance of cost efficiency in bioenergy industry to produce competitive and economical outputs in energy markets (Welfle *et al*., 2014).

The study problem is that the need for cost efficiency in bioenergy industry has become a significant need in EU28 Region. According to VDN, the total cost production of bioenergy has increased uring the period between 2000, 2007-2011 significantly by (1 million tonnes), (10 million tonnes), to reach (20 million tonnes), respectively. Based the National Renewable Energy Laboratory 2003, CO^2 emission from fossil fuel production and huge consumption for energy will not help the EU-28 countries to achieve the (NREAPs) main three targets by 2020 while the integration of biomass and fossil fuel energy production can achieve a significant reduction in the cost of production and CO_2 emission. Tromborg *et al*. (2013) has referred that the cost of bioenergy production has increased due to the enhancement in the biomass feedstock prices. Moreover, the high price of the biomass feedstock in EU28 region in compare with other regions (USA for example) is effect negatively in the total cost of bioenergy production and the economic competitiveness of bioenergy industry.

The main objective of this study is to measure the cost efficiency through applying data envelopment analysis method of bioenergy industry in the EU28 Region for the period between 1990 and 2013. The significant of this study is to measure and identify the cost efficiency of bioenergy industry indeveloping and developed countries in EU28 region. Moreover, find the factors which impacts to reduce the total cost of bioenergy production in order to decrease the prices of bioenergy production output to be competitive in the energy market. Also, increase the outputs of bioenergy production through scale economic to achieve competitive output prices and meet the National Renewable Energy Action Plans (NREAP) 2020 targets. The cost efficient of bioenergy production will help EU28 region to decrease the input and input costand producing the same level of output, this will reduce the imported biomass used in bioenergy production and decrease the total cost of bioenergy production. Consequently, the cost efficiency in bioenergy production will cause a decrease in CO_2 emission, increase the use of bioenergy production as source of renewable energy in different sectors (electricity, power, heat, cool and fuel), decrease the use of fossil fuel to produce energy.

An overview for cost efficiency of bioenergy industry: The key aim of this part is to discuss previous articles related to two main points. Firstly,empirical results pertaining to cost efficiency of bioenergy industry in particular. Secondly, the employed Data Envelopment Analysis (DEA) as a statistical method to measure cost efficiency in different industries. This part is much more interesting because it will provide a full picture of the three types of relevant efficiency (cost, allocative and technical) measure are linked to one another. Starting with first aim; Ilic *et al*. (2014) has found that in Sweden energy market, the price ration of biomass used as feedstock play a significant role in the profitability of biofuel (ethanol+ biogas) production output (Ilic *et al*., 2014). Due to the high efficiency of biofuel, ethanol production stations have produced upgraded biogas (biofuel) has the lowest cost in transportation energy market (Ilic *et al*., 2014). Pihl *et al*. (2010) has applied techno economic analysis for the integration of bioenergy and fossil fuel industries in EU countries. The integration of Biomass Thermal Conversion (BTC) with Combined Cycle Gas Turbine (CCGT) can achieve higher efficiency and lower production cost for power in the short term in compare with other standalone plants (Pihl *et al*., 2010). Berndes *et al*. (2010) has presented two methods to improve the 2nd generation biofuels depends on biomass (lighocellulosic) feedstock. First method, the combination of gasification based biofuel stations in district heating system can impact significantly to increase the energy efficiency and enhance the economic competitiveness of biofuel outputs. Second method, the integration of biomass co-firing with coal to produce high efficiency biomass electricity (bioelectricity) outputs and mitigate the CO_2 emissions by substituting coal (Berndes *et al*., 2010). Tye *et al*. (2011) has indicated to that Second Generation Bioethanol (SGB) significant role as potential energy source for Malaysian transportation sector in future. Due to the importance role of agriculture industry in Malaysia, the agricultural waste (biomass) has become a pretty promising alternative source for SGB production. SGB can cover close to 21.5% of the national energy requirement, key drivers to transfer toward renewable and sustainable energy sources, potential for security energy, mitigate CO^2 emissions and economically feasible (Tye *et al*., 2011). Balat and Balat (2009) have founds that hydrogen (bioenergy) production from biomass is the most economical strategy among the current commercial strategies to produce hydrogen. The cost of hydrogen production depends widely on the biomass feedstock price. Therefore, cost efficiency of hydrogen production from biomass can be achieved with proper improvement for the biomass feedstock generated from agriculture waste and different sources for biomass to produce economical hydrogen (Balat and Balat, 2009). Hoogwijk *et al*. (2008) has referred to that the land productivity improvement and cost reduction through learning, capital and labor development, can plays main roles to reduce the total cost of bioenergy production from biomass sources (such as energy crops, agriculture lands, etc.) to compete in future with electricity production in some regions such as Former USSR, Oceania, Western and Eastern Africa and East Asia (Hoogwijk *et al*., 2008).

Prospects of cost efficiency decompositions: The second aim of this part is to discuss the previous papers employed DEA statistical method in more details. As a short introduction for the different concepts of efficiency, Technical Efficiency (TE) refers to the optimal use of available resources (inputs) in the production process (output), maximal output from the available inputs. However, if information on input prices is available and if cost minimization is assumed for all EU28 Region members then a DEA model isappropriate to additionally compute the Allocative Efficiency (AE) and the total (economic) Cost Efficiency (CE) of the relevant EU28 members. In other words, technical efficiency is focused on the quantity of inputs only, while allocative efficiency is more relevant for optimal mix of inputs with minimum cost. Theses combination of technical and allocative efficiency can be called cost (or economic) efficiency. An advantage of DEA in compare to parametric methods is that it does not need any assumption on the functional form of cost or production frontiers. Moreover, DEA does not have to assume that country always aim to minimize cost. A disadvantage of DEA is that it does not cater for stochastic error Study by Staub *et al*. (2010) is among different studies which measuredthe cost efficiency, technical efficiency and allocative efficiency for Brazilian banks for the period between 2000 and 2002 through Data Envelopment Analysis (DEA) to calculate the efficiency scores. Staub *et al*. (2010) has found that cost (economic) efficiency level is low in compare with Europe and USA banks, due to the low level of technical efficiency in compare with allocative efficiency.

The study by Hassan and Hussein (2003) is among the earliest to investigate the cost efficiency of Islamic Sudanese banks systems by DEA method during the period between 1992 and 2000. Hassan and Hussein (2003) have found that the cost inefficiency can be justified due to the low level of allocative efficiency in compare with technical efficiency Hassan and Hussein (2003). Merkert and Hensher (2011) have examined the cost efficiency of (58) airlines (aviation) market among the world through employing the data envelopment analysisapproach for the period between 2007 and 2009. Merkert and Hensher (2011) have found that high level of cost efficiency is limited to airlines technical efficiency in compare with airlines allocative efficiency. Abramo *et al.* (2011) has employed the DEA statistical method to measure the cost efficiency, technical efficiency and allocative efficiency for bibliometric data from (78) Italian university system for the period between 2004 and 2008. Abramo *et al.* (2011) has found that cost inefficiency resulted due to the low level of technical efficiency in compare to allocative efficiency. Tsionas *et al.* (2014) has examined the performance of of European banks during the world crisis for the period between 2005 and 2012 in term of cost efficiency for the short and long term. Tsionas *et al.* (2014) has found that the performance of cost efficiency has been impacted significantly by the low level of technical efficiency in compare with allocative efficiency. Haelermans and Ruggiero (2012) have employed the statistical method of DEA to compute cost efficiency and have the cost efficiency decomposition analyzed in Dutch secondary school in Netherland. The result has reveal that cost efficiency is more affected by the dominated allocative efficiency in compare with technical efficiency Haelermans and Ruggiero (2012).

MATERIALS AND METHODS

Model specification: The main target of this part is first of all to identify the first stage of employed DEA statistical method, then after, to present the hired input and output variables in DEA method. Firstly, the scale ofcost efficiency is realizedby employing the DEA statistical method. The DEA mathematical approach frames a frontier of the observation of input and output ratio through linear programming techniques. The linear programming substitution is acceptable between observed input groups on an isoquant (the same volume of output is generated while amending the volume of two or more inputs) that was assumed by theDEA statistical method. The root of DEA was started by Charnes *et al.* (1978) who has created the firstversionof DEA method to measure the efficiency of each decision making unit (e.g., region, country, firm), the measurement can be acheived as a maximum of a ratio of weighted outputs to weighted inputs. The more output produced from available inputs, the more efficient DMU can be identified. This articleemployed efficiency assessment under the Variable Returns to Scale (VRS) hypothesis. The VRS hypothesis was provided by Banker *et al.* (1984). The Banker, Charnes and Cooper (BCC) structured model (VRS) exended the Charnes, Cooper and Rhodes (CCR) model which was first initiated by Charnes *et al.* (1978) by relieve the constant return to measure (CRS) hypothesis. The framed BCC model was applied to assessthe efficiency of DMUs specified by VRS hypothesis. Moreover, outcomes have concluded from the VRShypothesis provides extratrustworthy information on DMUs' efficiency in comparewith CRS hypothesis (Coelli *et al.*, 1998).The cost efficiency model is provided in Eq. 1 as follow:

$$\min \sum_{i=1}^{m} p_i^0 \tilde{x}_{io} \quad (1)$$

Where (M) refer to the input observation, (i) indicate to (m^{th}) input, (p^0_r) point to unit price of the input (i) of DMU0, ($\tilde{y}_{io}$) is (rth) output that maximize revenue for DMU0,(x_{io}) is (ith) input that minimize cost for DMU0, As resulted, the cost, allocative and technical efficiencies scores are limited between the values (0) and (1) range. In order to choose the optimum weights we have chosen the mathematical programming problem subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \tilde{x}_{io} \quad i = 1, 2, ..., m \quad (2)$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \tilde{Y}_{io} \quad i = 1, 2, ..., s \quad (3)$$

While (y_{ro}) is (rth) output for DMU0, (x_{io}) is (ith) input for DMU0, (n) is DMU observation, ($_j$) is (nth) DMU,(λ_j) is non-negative scalars, (y_{rj}) is (sth) output for (nth) DMU and () is (mth) input for (nth) DMU (Zhu, 2009):

$$\lambda_j \tilde{x}_{io} \geq 0 \quad (4)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad (5)$$

By calculating the three efficiency types, we will be able to observe more robust result for the bioenergy industry developed and developing countries in EU28 region over the period between 1990 and 2013. However, the present study point's greater emphasis on the cost (economic)efficiency measure compared to the other decomposition efficiency measures (e.g., allocative and technical).

The second target of this section is to identify the inputs and outputs variables in DEA depends on

Table 1: List of EU28 region member countries

Developed countries (15)		Developing countries (13)	
Member countries	Years of entry	Member countries	Years of entry
Austria	1995	Bulgaria	2007
Belgium	1958	Croatia	2013
Denmark	1973	Cyprus	2004
Finland	1995	Czech republic	2004
France	1958	Estonia	2004
Germany	1958	Hungary	2004
Greece	1981	Latvia	2004
Ireland	1973	Lithunia	2004
Italy	1958	Malta	2004
Luxemboug	1958	Poland	2004
Netherlands	1958	Romania	2007
Portugal	1986	Slovakia	2004
Spain	1986	Slovenia	2004
Sweden	1995		
United Kingdom	1973		

previous study (Cooper *et al*., 2007). There is a standard requirement to be achievedin order to selectthenumber of inputs, input price and outputs.The basic rule Eq. 6 which can provide instruction can be presented as:

$$n \geq \max \{m \times s, 3(m+s)\} \quad (6)$$

Where:

n = Points to the number of DMUs
m = Indicates to the number of inputs
s = Refer to the number of outputs

Providing the underdevelopment of bioenergy industry in EU28, the significance of efficiency of bioenergy production is critical as a main source ofrenewable and sustainable energy. Therefore, it is reasonable to suppose that the efficiency of bioenergy industry in terms of their intermediation function is crucial as an effective channel to give energy for varioussections from renewable and sustainable sources. In this vein Ilic *et al*. (2014) has pointed out that bioenergy industry play an important economic role in providing renewable and sustainable source of energy by converting biomass into energy and contribute to develop the economic sector.

As notified by variousarticles to the significant role of efficiency in bioenergy industry in growth economic (Pihl *et al*., 2010; Berndes *et al*., 2010; Tye *et al*., 2011; Balat and Balat, 2009; Hoogwijk *et al*., 2008). Following Staub *et al*. (2010), Hassan and Hussein (2003), Merkert and Hensher (2011), Abramo *et al*. (2011), Tsionas *et al*. (2014) and Haelermans and Ruggiero (2012) among others, the present study used the economic efficiency approach which views cost efficiency as the solution to develop the bioenergy industry in EU28 countries. Accordingly,three inputs, three inputs prices and one outputvariables were chosen. The three input vector variables consist of x1: raw material, x2: labor and x3 physical capital. Accordingly, the input prices are w1: price of raw material, w2 price of labor and w3 price of physical capital. The output vector is y1: production.

Data collection: The present study collects data on the bioenergy industry from European Union (EU28) countries which are listed in Table 1, for the period between 1990 and 2013. The main source of biomass and bioenergy data is the EUROSTAT database produced by the European Union Commission which provides all related data for biomass and bioenergy industry. We obtained data related to the used input (raw material, labor and capital) input price (raw material price, labor price, capital price) and output (bioenergy production) variables from EUROSTAT databases. The final sample comprised (23) country operating in EU28 Region, can be divided into (15) developed countries and (13) developing countries in EU28 Region (Table 1). All input and output have been converted to Thousand TOE (tonnes of oil equivalent) for the purpose of comparability. Moreover, the input prices for different variables have been converted to Million Euros (ME).

RESULTS

Following many studies related to the same statistical approach such as Sufian and Kamurdin (2015), Gilani (2015), Omar and Jones (2015) and Sufian (2009). Table 2 shows the average of cost efficiency (0.44) and the decomposition into technical efficiency (0.87) exceeded allocative efficiency (0.53) of EU28 zone of bioenergy industry for the period between 2000 and 2013 which can reflect the EU28 zone inefficiency for the same study period resulted as cost inefficiency (1-cost efficiency = 1 -0.44 = 0.56) and the decomposition into allocative

Table 2: Average of cost efficiency of bioenergy industry in UE28 over 2000-2013

Efficiency (Year)	Average by developing country	Average by developing country	Average by EU28 countries
2000			
CE	0.35	0.36	0.36
AE	0.41	0.42	0.42
TE	0.90	0.91	0.91
2001			
CE	0.35	0.35	0.35
AE	0.42	0.43	0.43
TE	0.87	0.88	0.87
2002			
CE	0.35	0.35	0.35
AE	0.42	0.42	0.42
TE	0.89	0.90	0.89
2003			
CE	0.43	0.43	0.43
AE	0.52	0.52	0.52
TE	0.86	0.87	0.87
2004			
CE	0.40	0.40	0.40
AE	0.48	0.48	0.48
TE	0.87	0.88	0.87
2005			
CE	0.50	0.48	0.49
AE	0.56	0.54	0.55
TE	0.89	0.90	0.89
2006			
CE	0.47	0.46	0.46
AE	0.57	0.56	0.57
TE	0.87	0.88	0.87
2007			
CE	0.46	0.45	0.46
AE	0.46	0.45	0.46
TE	0.88	0.88	0.88
2008			
CE	0.38	0.38	0.38
AE	0.46	0.46	0.46
TE	0.85	0.86	0.85
2009			
CE	0.39	0.39	0.39
AE	0.49	0.48	0.49
TE	0.83	0.85	0.84
2010			
CE	0.44	0.44	0.44
AE	0.53	0.53	0.53
TE	0.85	0.85	0.85
2011			
CE	0.44	0.44	0.44
AE	0.53	0.53	0.53
TE	0.85	0.85	0.85
2012			
CE	0.54	0.53	0.53
AE	0.68	0.66	0.67
TE	0.80	0.81	0.81
2013			
CE	0.62	0.61	0.61
AE	0.73	0.71	0.72
TE	0.87	0.87	0.87
Average by year			
CE	0.44	0.44	0.44
AE	0.53	0.52	0.53
TE	0.86	0.87	0.87

inefficiency (1-allocative efficiency = 1-0.53 = 0.47) overrides technical inefficiency (1-technical efficiency = 1-0.87 = 0.13). Table 2 shows the mean cost, allocative and technical efficiencies of developing and developed countries in bioenergy for the period between 2000 and 2013. The empirical findings seem to indicate that the developing and developed countries have exhibited equal means in cost efficiency (0.44 vs 0.44), where developing countries have presented higher allocative efficiency value in compare with developed countries as follow and respectively (0.53 vs 0.52). But not technical efficiency where mean of developed countries is higher than developing countries as showed respectively (0.87 vs 0.86). Despite the fact that the empirical findings clearly highlight that both the developing and developed countries in bioenergy industry have been inefficient in producing outputs by using the available input and input prices resulted cost inefficiency, allocative inefficiency and technical inefficiency. Based on empirical findings in Table 2, (inefficiency = 1-efficiency) which clearly indicate that in developing and developed countries the level of cost inefficiencies are (0.56 vs 0.56), allocative inefficiencies are (0.47 vs 0.48), technical inefficiencies are (0.14 vs 0.13), respectively.

As for cost efficiency, the average developing and developed countries could only generate (0.44 vs 0.44) of output, less than what it was initially expected to generate. Hence, cost efficiency is lost by (0.56 vs 0.56) indicating that the average developing and developed countries loses an opportunity to receive (0.56 vs 0.56) more output given the same amount of resources or it could have produced (0.56 vs 0.56) of its outputs given the same level of inputs and inputs costs. This result shows that the developing countries are generating the same output and experiences less loses of input and saving in input cost compared to the developed countries for the period between 2000 and 2013, as the level of the cost efficiency in the developing countries is also equal to the one in developed countries. Regarding allocative efficiency, the results indicate that, on average, developing and developed countries have utilized only (0.53 vs 0.52) of inputs costs to produce the same level of outputs. In other words, on average, both developing and developed countries have wasted (0.46 vs 0.47) of its inputs costs, or it could have saved (0.46 vs 0.47) of its inputs costs to produce the same level of outputs. Noticeably, the level of the allocative efficiency is higher in developing countries than developed countries. This indicates that the developing countries are capable to choose the minimum costs for resources and involve with lower wastage of inputs costs. While, developed countries shows that they are selecting a high amount of inputs costs to produce outputs that lead to the higher wastage inputs costs for the study period between 2000 and 2013.

For the technical efficiency, the results seem to suggest that the average developing and developed countries could only utilize (0.86 vs 0.87) of what was available. Therefore, both developing and developed countries lost the opportunity to generate (0.14 vs 0.13) more optimal outputs from the minimum level of inputs that may lead to higher technical efficiency. The results state that the level of technical efficiency is higher in the developed countries compared to that in the developing countries. This implies that developed countries are capable of producing more outputs by utilizing less input to generate with higher technical efficiency. Meanwhile, developing countries are utilizing more inputs and produce fewer outputs that may lead to the lower technical efficiency. In conclusion, the empirical findings from this study seem to suggest that the developing countries have exhibited an equal cost efficiency level in compare with developed countries (0.44 vs 0.44). Moreover, developing countries have showed higher value in allocative efficiency in compare with developed countries (0.53 vs 0.52), respectively. On the other hand, the empirical finds from this study seem also to suggest that the developing countries have exhibited a lower technical efficiency level in compare with developed countries level of technical efficiency measure (0.86 vs 0.87), respectively between 2000 and 2013. In essence, allocative efficiency and technical efficiency seems to plays the main factor, leading to lower or higher cost efficiency levels. Besides, results for the developing (or developed) countries shows that the level of cost efficiency is higher (or lower) than that of developed (or developed) due to the higher (or lower) allocative efficiency and technical efficiency, or lower (or higher) inefficiency level from the allocative efficiency and technical efficiency sides.

For the period between 1990 and 1999, the results present the means (refer Appendix A-G) of costs efficiency (0.41) and the decomposition into technical efficiency (0.77) exceeded allocative efficiency (0.54) of EU28 zone of bioenergy industry for the period between 1990 and 1999 which can reflect the EU28 zone inefficiency for the same study period resulted as cost inefficiency (0.59) and the decomposition into allocative inefficiency (0.46) overrides technical inefficiency (0.23). In the period between 1990 and 1999, the empirical findings seem to indicate that the developed countries have exhibited higher means in cost efficiency and allocative efficiency in compare with developing countries as follow and respectively: cost efficiency (0.54 vs 0.27), allocative efficiency (0.69 vs 0.39), but not technical efficiency where mean of developed countries is lower to the one in developing countries as showed (0.76 vs 0.78), respectively. Despite the fact that the empirical findings clearly highlight that both the developing and developed countries in bioenergy industry have been inefficient in producing outputs by using the available input and input cost resulted cost inefficiency, allocative inefficiency and technical inefficiency. The empirical findings are clearly indicate that in developing and developed countries the level of cost inefficiency is (0.46 vs 0.73), allocative inefficiency is (0.31 vs 0.61), technical inefficiency is (0.24 vs 0.22) respectively for the period between 1990 and 1999 (refer Appendix A-G).

Parametric and non-parametric tests: After examining the results derived from the DEA method, the issue of interest now is whether the difference in the cost efficiency, allocative efficiency and technical efficiency of developing and developed countries is statistically significant or not. Mann Whitney Wilcoxon test is a relevant test for two independent samples coming from populations having the same distribution. The most relevant reason is that the data violate the stringent assumptions of the independent group's t-test. Hereby, we perform the non-parametric Mann Whitney Wilcoxon test along with a series of other parametric (t-test) and non-parametric Kruskall Wallis tests to obtain more robust results. Figuer 1 shows detailed results for robustness tests for developing and developed countries in bioenergy industry between the period 2000 and 2013.

In t-test for the year 2000, the mean of (CE) is statistically insignificance, because p-value is greater than the significant level at 1% as follow (0.014>0.01), where (AE) is statistically significance because p-value is lesser than the significant level at 1% as follow (0.003<0.01), while (TE) is statistically insignificance, because p-value is greater than the significant level at 10% as follow (1.11 >0.10). Moreover, in Mann Whitney test for the same year 2000, the mean of (CE) is statistically insignificance, because p-value is greater than statistical level at 1% as follow (0.016>0.01) where (AE) is statistically significance because p-value is lesser than the significant level at 1% as follow (0.003<0.01), while (TE) is statistically insignificant because p-value is greater than the significant level at 10% as follow (0.22>0.10). Furthermore, in Kruskal Wallis test for the same year 2000, the mean of (CE) is statistically insignificance because p-value is greater than the statistical level at the level 1% as follow (0.016>0.01) where (AE) is statistically insignificance because p-value is greater than the statistical level at 1% as follow (0.016>0.01) while (TE) is statistically insignificant because p-value is greater than the significant level at 10% as follow (0.22 >0.10).

Detailed of Parametric and Non-Parametric Tests

		Parametric Test						Non-Paramentric test											
		t-test						Mann Whitney Wilcoxon test						Kruskal Wallis					
Year	Group	CE	t	AE	t	TE	t	CE	Z	AE	Z	TE	Z	CE	Chi-Square	AE	Chi-Square	TE	Chi-Square
2000	Developing	0.3515	-2.639	0.4138	-3.247	0.9023	1.11	10.46	-2.42	9.85	-2.789	16.42	-1.214	10.46	5.858	9.85	7.78	16.42	1.473
	Developed	0.622	(0.014)**	0.7553	(0.003)**	0.8153	(0.277)	18	(0.016)**	18.53	(0.005)***	12.83	(0.225)	18	(0.016)**	18.53	(0.016)**	12.83	(0.225)
2001	Developing	0.35	-3.021	0.4354	-3.281	0.8708	0.533	10.15	-2.604	9.73	-2.858	15.5	-0.624	10.15	6.781	9.73	8.166	15.5	0.389
	Developed	0.6427	(0.006)***	0.7633	(0.003)***	0.8267	(0.599)	18.27	(0.009)***	18.63	(0.009)***	13.63	(0.533)	18.27	(0.009)***	18.63	(0.004)***	13.63	(0.533)
2002	Developing	0.3454	-2.698	0.4192	-2.985	0.8877	0.647	10.31	-2.513	10.54	-2.375	16.5	-1.302	10.31	6.313	10.54	5.64	16.5	1.695
	Developed	0.638	(0.012)**	0.748	(0.007)***	0.8353	(0.524)	18.13	(0.533)	17.93	(0.018)**	12.77	(0.193)	18.13	(0.012)**	17.93	(0.018)**	12.77	(0.193)
2003	Developing	0.4331	-1.664	0.5215	-1.833	0.8654	0.392	12.08	-1.452	12.08	-1.452	15.88	-0.886	12.08	2.109	12.08	2.109	15.88	0.786
	Developed	0.6233	(0.108)	0.7267	(0.080)*	0.8333	(0.698)	16.6	(0.146)	16.6	(0.146)	13.3	(0.375)	16.6	(0.146)	16.6	(0.146)	13.3	(0.375)
2004	Developing	0.4069	-2.488	0.4838	-3.069	0.87	0.433	11.35	-1.89	11.35	-1.890	15.27	-0.493	11.35	3.574	10	7.278	15.27	0.243
	Developed	0.6407	(0.020)**	0.7467	(0.005)***	0.8367	(0.669)	17.23	(0.059)*	17.23	(0.007)***	13.83	(0.622)	17.23	(0.059)*	18.4	(0.007)***	13.83	(0.622)
2005	Developing	0.4962	-1.271	0.5615	-1.709	0.8892	0.659	12.35	-1.291	11.38	-1.867	15.46	-1.867	12.35	1.666	11.38	3.485	15.46	0.379
	Developed	0.626	(0.215)	0.7213	(0.100)*	0.844	(0.516)	16.37	(0.197)	17.2	(0.062)*	13.67	(0.538)	16.37	(0.197)	17.2	(0.197)	13.67	(0.538)
2006	Developing	0.5208	-0.813	0.6162	-1.696	0.8708	1.417	12.23	-1.361	11.69	-1.684	15.73	-0.788	12.23	1.853	11.69	2.837	15.73	0.621
	Developed	0.6053	(0.424)	0.7653	(0.104)	0.754	(0.169)	16.47	(0.173)	16.93	(0.092)*	13.43	(0.431)	16.47	(0.173)	16.93	(0.092)*	13.43	(0.431)
2007	Developing	0.4623	-1.997	0.5346	-2.84	0.8754	0.667	11.69	-1.685	10.46	-2.423	15.54	-0.665	11.69	2.838	10.46	5.873	15.54	0.442
	Developed	0.664	(0.056)*	0.7787	(0.009)***	0.8233	(0.511)	16.93	(0.092)*	18	(0.015)**	13.6	(0.506)	16.93	(0.092)*	18	(0.015)**	13.6	(0.506)
2008	Developing	0.3792	-2.306	0.4577	-2.643	0.8492	0.187	10.85	-2.192	10.62	-2.331	15.23	-0.468	10.85	4.805	10.62	5.435	15.23	0.219
	Developed	0.624	(0.029)**	0.722	(0.014)**	0.8353	(0.853)	17.67	(0.028)**	17.87	(0.02)**	13.87	(0.64)	17.67	(0.028)**	17.87	(0.02)**	13.87	0.64
2009	Developing	0.3915	-1.728	0.4915	-1.587	0.8354	-0.051	12.08	-1.454	12.27	-1.338	15.04	-0.345	12.08	2.114	12.27	1.79	15.04	0.119
	Developed	0.5753	(0.096)*	0.6533	(0.125)	0.8393	(0.960)	16.6	(0.146)	16.43	(0.181)	14.03	(0.73)	16.6	(0.146)	16.43	(0.181)	14.03	(0.73)
2010	Developing	0.44	-1.763	0.5354	-2.076	0.8508	0.378	12.15	-1.408	11.65	-1.708	15.46	-0.60	12.15	1.983	11.65	2.918	15.46	0.36
	Developed	0.614	(0.090)*	0.72	(0.048)**	0.822	(0.709)	16.53	(0.159)	16.97	(0.088)*	13.67	(0.549)	16.53	(0.159)	16.97	(0.088)*	13.67	(0.549)
2011	Developing	0.54	-0.498	0.6815	-0.282	0.8008	-0.264	13.77	-0.438	14.08	-0.254	14.31	-0.119	13.77	0.192	14.08	0.064	14.31	0.014
	Developed	0.5947	(0.623)	0.7093	(0.780)	0.8227	(0.794)	15.13	(0.661)	14.87	(0.800)	14.67	(0.905)	15.13	(0.661)	14.87	(0.8)	14.67	(0.905)
2012	Developing	0.51	-0.966	0.6262	-0.964	0.8269	-0.218	12.77	-1.038	13.23	-0.761	14.31	-0.123	12.77	1.078	13.23	0.58	14.31	0.015
	Developed	0.6053	(0.343)	0.7153	(0.345)	0.844	(0.829)	16.00	(0.299)	15.6	(0.446)	14.67	(0.902)	16	(0.299)	15.6	(0.446)	14.67	(0.902)
2013	Developing	0.6238	-0.059	0.7262	-0.216	0.8708	0.24	14.92	-0.254	14.23	-0.162	15.5	-0.631	14.92	0.064	14.23	0.026	15.5	0.399
	Developed	0.6293	(0.954)	0.744	(0.830)	0.852	(0.812)	14.13	(0.800)	14.73	(0.872)	13.63	(0.528)	14.13	(0.8)	14.73	(0.872)	13.63	(0.528)

- Note: ***, ** and * indicate significance at the 1%, 5%, and 10% levels respectively - Values in parentheses are P-values

Fig. 1: Details of parametric and non-parametric mean tests during 2000-2013

In 2006, t-test results have presented that means of (CE), (AE) and (TE) are statistically insignificance because of p-values are greater than the statistical level at 10% as follow (0.424>0.10), (0.104>0.10) and (0.169>0.10), respectively. Moreover, in Mann Whitney test for the same year 2006, (CE) is statistically insignificance because of p-value is >the statistical level at 10% as follow (0.173 >0.10) while (AE) is statistically significance because p-value is lesser than the statistical level at 10% as follow (0.092<0.10) where (TE) is statistically insignificance because of p-value is >the statistical level at 10% as follow (0.431>0.10). Further more, in Kruskal Wallis test for the same year 2006 (CE) is statistically insignificance because of p-value is>the statistical level at 10% as follow (0.173 >0.10) while (AE) is statistically significance because p-value is lesser than the statistical level at 10% as follow (0.092<0.10) where (TE) is statistically insignificance because of p-value is >the statistical level at 10% as follow (0.431>0.10).

In t-test for the year 2013, (CE) is statistically insignificance because of p-value is greater than the statistical level at 5% as follow (0.059>0.05) where (AE) is statistically insignificance because of p-value is greater than the statistical level at 1% as follow (0.016>0.01) while (TE) is statistically insignificance because of p-value is greater than the statistical level at 10% as follow (0.24> 0.10). Moreover, in Mann Whitney test for the year 2013 the results have referred to that (CE), (AE) and (TE) are statistically insignificance because the p-values are greater that the statistical level at 10% as follow (0.254> 0.10), (0.162>0.10) and (0.528>0.10), respectively. Furthermore, in Kruskal Wallis test for the year 2013 the findings have referred to that (CE) is statistically insignificance because of p-value is greater than the statistical level at 5% as follow (0.064>0.05) where (AE) is statistically significance because of p-value is lesser than the statistical level at 5% as follow (0.026<0.05), while (TE) is statistically insignificance because of p-value is greater than the statistical level at 10% as follow (0.399>0.10) (Fig. 1).

The results from the parametric t-test in Table 3 for the period between 2000 and 2013 suggest that the developed countries have exhibited a higher average mean of cost efficiency in compare to the one in

Table:3 Summary of parametric and non-paramatric mean tests during 2000-2013

	Parametric test		Non-parametric test			
Individual test	t-test t (Prb>t)		Mann-Whitney Wilcoxon test z (Prb>z)		Kruskall-Wallis test (Prb>X^2)	
Hypothesis test						
Test statistics	Mean (n)	t	Mean rank	z	Mean rank	X^2
Cost efficiency						
Developing countries	10.53	-1.707	14.273	-1.571	14.337	2.944
Developed countries	10.54	(0.220)	14.414	(0.235)	14.473	(0.191)
Allocative efficiency						
Developing countries	10.63	-2.230	14.294	-1.706	14.288	3.855
Developed countries	30.64	(0.165)	14.475	(0.190)	14.469	(0.230)
Technical efficiency						
Developing countries	30.45	-0.437	14.597	-0.723	14.597	0.511
Developed countries	30.45	(0.585)	14.494	(0.516)	14.494	(0.544)

developing countries (0.53>0.54) respectively, statistically significant at 5% level. Likewise, the average mean related to allocative efficiency in developed countries have also exhibited a higher value in compare to the average mean of allocative efficiency in developing countries (0.64> 0.63), respectively statistically significant at the 5% level. In the other hand, the developed countries have exhibited equal average mean technical efficiency level to the one in developing countries (0.84 = 0.84) which statically insignificant because p-value is greater than the significant level at 10% (0.1). There was a statistically significant difference between the means of developing and developed countries in cost, allocativeand efficiency. Therefore, the study has rejected the null hypothesis and accepted the alternative hypothesis that there is difference in reading scores between the means of developing and developed countries (Table 3).

The results from the non-parametric test Mann Whitney Wilcoxon test in Table 3 for the period between 2000 and 2013 suggest that developed countries have presented a higher average mean cost efficiency level compared to the developing countries average mean (14.47>14.34), respectively and statistically significant at the 5% level. Likewise, developed countries have also exhibited a higher average mean of allocative efficiency in compare to the one in developing countries (14.48>14.29) respectively and statistically significant at the 10% level. Nevertheless, the developed countries average mean of technical efficiency have exhibited higher value in compare to the one in developing countries (14.60>14.49) which statically insignificant because p-value is greater than the significant level at 10% (0.1). There was a statistically significance difference between the means of developing and developed countries in cost and allocative efficiency. Therefore, the study has rejected the null hypothesis and accepted the alternative hypothesis that there is difference in reading scores between the means of developing and developed countries.

The results from the non-parametric test Kruskall Wallis test in Table 3 for the period between 2000 and 2013 suggest that the developed countries have exhibited a higher average mean of cost efficiency level in compare to the one in developing countries (14.47>14.34) respectively and statistically significant at the 5% level. Likewise, the developed countries have also exhibited a higher average mean of allocative efficiency level in compare to the one in developing countries (14.47>14.29) respectively and statistically significant at the 5% level. In the other hand, the developing countries have exhibited higher average mean technical efficiency level in compare to the one in developed countries (14.60>14.49) respectively which statically insignificant which statically insignificant because p-value is greater than the significant level at 10% (0.1). There was a statistically significant difference at the level 5% (= 0.05) between the means of developing and developed countries for both cost and allocativeefficiency. Therefore, the study has rejected the null hypothesis and approved the alternative hypothesis that there is difference in reading scores between the means of developing and developed countries.

Regarding the period between 1990 and 1999, the results from parametric test (t-test) and non-parametric (Mann Whitney Wilcoxon and Kruskall Wallis) tests suggests that the developed countries have exhibited a higher average means of cost efficiency and allocative efficiency values in compare to the ones in developing countries, with statistically significant at the 5% levels for cost and allocative efficiency (Refer Appendix G). On the other hand, the results from non-parametric Mann Whitney Wilcoxon test and Kruskall Wallis test suggests that developing countries have exhibited a higher average means of technical efficiency compared to the ones in developed countries for the period between 1990 and

1999. However, in parametric test (t-test) the average means of technical efficiency in developing and developed countries are equal for the value of (0.74),) which statically insignificant because p-value is greater than the significant level at 10% (0.1) (Appendix A-G).

DISCUSSION

The results have remarked and concluded that the means of cost efficiency in developing and developed countries in EU28 Region are equal, supposingthe sameloss of inputs by developing and developed countries.The analysis of cost efficiency has indicated thatthe mean of allocative efficiency overridetechnical efficiency influence in EU28 developing countries. Moreover, the analysis of cost efficiency has referred to that technical efficiency exceed the allocative efficiency impacts in EU28 developed countries. Furthermore, bioenergy industry has exhibited relatively equalmeans of economic (cost) efficiency in developing and developed countries during the period between 2000 and 2013.The results indicated to that in developing countriesallocative efficiency is override technical efficiency, where the participating of technical inefficiency is exceedallocative inefficiency influence in EU28 bioenergy industry. However, the results pointed to that in developed countries the means of technical efficiency is overrideallocative efficiency, where the participating of allocative inefficiency is outweighs technical inefficiency in EU28 bioenergy industry. Therefore, our results do not encourage morereallocating for the available input mixes in bioenergy production in developing countries, because in furtherreallocating for available resources will only result smaller enhancement in output for every proportionate enhancement in reallocating forinputs mixes, giving fromthe fact that EU28 bioenergy industry has been producing at decreasing returns to scale between the period 2000 and 2013. However, our results suggests more works to be made for human capital and skilled workersby attaining optimal utilization of capability, development in managerial level, technical skilled expertise and maximum productive scale in generation of bioenergy industry in EU28. This can boost the efforts directions forsustainable and competitiveness production in bioenergy industry in the future. On the other hand, our results do not suggestmore dvelopment for financial regulation and performance for the bioenergy production in developed countries, but proper reallocating for the available input mixes (raw material, labor, capital, etc.) are significantly required. The Study has aided to analyze the cost efficiency of EU28 bioenergy industry during the period between 1990 and 2013. The employed Data Envelopment Analysis (DEA) statistical method has provided us the opportunity to verify three types of efficiency (cost, allocateive and technical efficiencies). Finally, we have employed non parametric tests (Mann Whitney U and Kruskal Wallis tests) and parametric test (t-test) to test whether the selected samples (developing and developed countries) were drawn from the same population or not. Our findings in (CE) Cost Efficiency from the parametric and non-parametric tests in Table 3 rejected the null hypothesis and accepted the alternative hypothesis due to that the average means of Cost Efficiency (CE) in developing and developed countries are differentand statistically significant because p-value is lesser than the statistical level at 5%, which is mean the selected samples were drawn from the different populations.Moreover, the results for Allocative Efficiency (AE) from the parametric and non-parametric tests in Table 3 have rejected the null hypothesisand accepted the alternative hypothesis which is mean the selected samples were drawn from the different populations, due to that the average means of Allocative Efficiency (AE) in developing and developed countries are different and statistically significant because p-value is lesser than the statistical level at 5%, 10% and 5% in the different employed t-test, Mann Whitney U test and Kruskal Wallis test respectively. Nevertheless, the results for Technical Efficiency (TE) from the parametric and non-parametric tests in Table 3 have rejected the null hypothesis and accepted the alternative hypothesis which is mean the selected samples were drawn from the different populations, due to that the average means of Technical Efficiency (TE) in developing and developed countries are different and statistically insignificant because p-value is reater than the statistical level at 10%.

CONCLUSION

Due to the study restrictions, the current study may be extended in different of ways. First, if data related tooutput prices is available, further analysis could be performed to investigate the overall revenue efficiency decomposition cost efficiency and profit efficiency. Second, interested researchers may employ the Malmquist Productivity Index method to test the sources of total factor productivity changes of bioenergy industry in EU28 countries. Third, to apply more robust results, empirical findings from the current study could be compared to the results derived from improved statistical methods, i.e., Bootstrap DEA.

APPENDICES

Appendix A: Cost efficiency of bioenergy industry in developing countries during 2000-2013

Year	2000			2001			2002			2003			2004			2005			2006			2007			2008			2009			2010			2011			2012			2013			Average By		
County	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE
Bulgaria	0.07	0.07	0.99	0.08	0.08	1.00	0.10	0.10	1.00	0.09	0.09	1.00	0.21	0.21	1.00	0.20	0.20	1.00	0.18	0.18	1.00	0.19	0.19	1.00	0.11	0.11	1.00	0.10	0.10	1.00	0.17	0.17	1.00	0.23	0.23	1.00	0.27	0.27	1.00	0.45	0.45	1.00	0.17	0.17	1.00
Czech Republic	0.57	0.82	0.70	0.54	0.70	0.76	0.00	0.00	0.81	0.60	0.74	0.81	0.50	0.61	0.81	0.65	0.70	0.92	0.66	0.71	0.93	0.60	0.62	0.96	0.52	0.59	0.88	0.52	0.66	0.78	0.54	0.62	0.87	0.67	0.91	0.73	0.64	0.84	0.76	0.79	0.92	0.86	0.55	0.67	0.83
Estonia	0.32	0.34	0.95	0.34	0.35	0.97	0.41	0.41	1.00	0.45	0.45	1.00	0.49	0.49	1.00	0.64	0.64	1.00	0.59	0.59	1.00	0.60	0.60	1.00	0.62	0.62	1.00	0.51	0.51	1.00	0.54	0.56	0.97	0.63	0.75	0.84	0.70	0.81	0.87	0.87	0.87	1.00	0.55	0.57	0.97
Croatia	0.24	0.24	1.00	0.19	0.23	0.83	0.19	0.22	0.90	0.13	0.13	1.00	0.23	0.25	0.92	0.27	0.29	0.93	0.32	0.32	1.00	0.32	0.32	1.00	0.14	0.14	1.00	0.14	0.14	1.00	0.16	0.16	1.00	0.16	0.17	0.95	0.21	0.21	1.00	0.48	0.48	1.00	0.23	0.24	0.97
Cyprus	0.19	0.68	0.28	0.21	0.93	0.23	0.23	0.98	0.23	0.26	0.96	0.27	0.24	0.64	0.37	0.24	0.42	0.56	0.24	0.99	0.24	0.19	0.53	0.37	0.21	0.59	0.35	0.19	0.71	0.27	0.18	0.68	0.27	0.16	0.66	0.24	0.17	0.61	0.28	0.18	0.81	0.22	0.21	0.73	0.30
Latvia	0.25	0.25	1.00	0.23	0.25	0.93	0.24	0.24	1.00	0.42	0.42	1.00	0.55	0.55	1.00	0.93	0.93	1.00	0.74	0.74	1.00	0.78	0.78	1.00	0.60	0.60	1.00	0.53	0.53	1.00	0.61	0.61	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	0.63	0.64	0.99
Lithuania	0.20	0.24	0.83	0.25	0.40	0.61	0.26	0.44	0.60	0.19	0.34	0.56	0.27	0.44	0.61	0.31	0.45	0.69	0.35	0.51	0.68	0.31	0.45	0.68	0.25	0.35	0.70	0.26	0.41	0.63	0.39	0.55	0.72	0.47	0.68	0.68	0.43	0.66	0.65	0.58	0.76	0.76	0.32	0.48	0.67
Hungary	0.50	0.51	0.98	0.53	0.54	0.99	0.68	0.68	1.00	0.56	0.67	0.84	0.47	0.77	0.61	0.52	0.93	0.56	0.49	0.78	0.62	0.51	0.86	0.59	0.48	0.76	0.63	0.56	0.86	0.66	0.54	0.83	0.65	0.57	0.95	0.60	0.62	0.86	0.72	0.65	0.83	0.79	0.55	0.77	0.73
Malta	1.00	1.00	1.00	0.79	0.79	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.98	1.00
Poland	0.40	0.40	1.00	0.51	0.51	1.00	0.54	0.54	1.00	0.31	0.31	1.00	0.41	0.41	1.00	0.41	0.46	0.90	0.38	0.41	0.91	0.38	0.44	0.86	0.28	0.35	0.79	0.29	0.38	0.77	0.37	0.48	0.77	0.39	0.51	0.78	0.35	0.43	0.81	0.53	0.68	0.84	0.40	0.45	0.89
Romania	0.15	0.15	1.00	0.13	0.13	1.00	0.18	0.18	1.00	0.14	0.19	0.77	0.25	0.25	1.00	0.28	0.28	1.00	0.45	0.45	1.00	0.47	0.47	1.00	0.22	0.22	1.00	0.22	0.22	1.00	0.31	0.31	1.00	0.43	0.43	1.00	0.39	0.39	1.00	0.58	0.58	1.00	0.30	0.30	0.98
Slovenia	0.60	0.60	1.00	0.59	0.59	1.00	0.54	0.54	1.00	0.48	0.48	1.00	0.47	0.47	0.99	0.54	0.54	1.00	0.50	0.56	0.89	0.41	0.44	0.92	0.26	0.38	0.69	0.31	0.41	0.75	0.33	0.41	0.81	0.37	0.63	0.59	0.41	0.62	0.66	0.67	0.78	0.85	0.46	0.53	0.87
Slovakia	0.08	0.08	1.00	0.16	0.16	1.00	0.12	0.12	1.00	1.00	1.00	1.00	0.20	0.20	1.00	0.47	0.47	1.00	0.21	0.21	1.00	0.25	0.25	1.00	0.24	0.24	1.00	0.46	0.46	1.00	0.58	0.58	1.00	0.94	0.94	1.00	0.44	0.44	1.00	0.34	0.34	1.00	0.39	0.39	1.00
Average By County	0.35	0.41	0.90	0.35	0.43	0.87	0.35	0.42	0.89	0.43	0.52	0.86	0.40	0.48	0.87	0.50	0.56	0.89	0.47	0.57	0.87	0.46	0.54	0.88	0.38	0.46	0.85	0.39	0.49	0.83	0.44	0.53	0.85	0.54	0.68	0.80	0.51	0.63	0.83	0.62	0.73	0.87	0.44	0.53	0.86

Appendix B: Cost Efficiency of bioenergy industry in developed countries over 2000-2013

Year	2000			2001			2002			2003			2004			2005			2006			2007			2008			2009			2010			2011			2012			2013			Average By		
County	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE
Belgium	0.47	0.71	0.66	0.55	0.76	0.72	0.46	0.66	0.69	0.38	0.57	0.68	0.37	0.61	0.61	0.34	0.57	0.60	0.27	0.51	0.52	0.33	0.59	0.56	0.48	0.77	0.62	0.32	0.48	0.66	0.41	0.61	0.68	0.26	0.38	0.68	0.27	0.40	0.67	0.42	0.57	0.74	0.38	0.58	0.65
Denmark	0.50	0.98	0.51	0.51	0.98	0.52	0.43	0.82	0.53	0.49	0.91	0.54	0.45	0.86	0.52	0.40	0.75	0.53	0.37	0.72	0.52	0.36	0.70	0.51	0.29	0.55	0.52	0.29	0.55	0.52	0.30	0.61	0.49	0.32	0.71	0.45	0.37	0.83	0.45	0.45	0.99	0.45	0.39	0.78	0.50
Germany	0.71	0.91	0.78	0.77	0.92	0.83	0.85	0.98	0.87	0.89	0.89	1.00	0.92	0.92	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.97	0.96
Ireland	0.16	0.30	0.52	0.18	0.36	0.51	0.21	0.33	0.63	0.16	0.30	0.53	0.38	0.62	0.61	0.42	0.62	0.68	0.38	0.63	0.60	0.48	0.74	0.65	0.24	0.38	0.63	0.20	0.30	0.66	0.30	0.46	0.65	0.30	0.58	0.53	0.34	0.58	0.59	0.43	0.79	0.54	0.30	0.50	0.60
Greece	0.29	0.29	1.00	0.33	0.38	0.86	0.32	0.40	0.81	0.30	0.36	0.84	0.43	0.55	0.78	0.44	0.53	0.84	0.54	0.63	0.85	0.56	0.65	0.86	0.31	0.35	0.86	0.22	0.33	0.67	0.28	0.37	0.76	0.39	0.56	0.70	0.45	0.67	0.67	0.48	0.68	071	0.38	0.48	0.80
Spain	0.65	0.74	0.87	0.70	0.80	0.87	073	0.85	0.87	0.72	0.87	0.83	0.73	088	0.83	0.81	0.97	0.84	0.85	0.97	088	0.87	0.98	0.89	0.81	0.95	0.85	085	0.89	0.96	0.91	0.96	0.94	0.91	098	0.93	0.89	0.98	0.91	0.95	0.97	099	0.81	091	0.89
France	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	100	1.00
Italy	0.39	0.90	0.43	0.37	0.90	0.41	0.33	0.81	0.41	0.29	0.70	0.41	0.33	0.66	0.49	0.29	0.58	0.49	0.26	0.58	0.45	0.25	0.58	0.43	0.39	0.68	0.57	0.38	0.59	0.65	0.44	0.84	0.53	0.42	0.83	0.51	0.52	0.84	0.62	0.46	0.76	060	0.36	073	0.50
Luxembourg	0.73	0.89	0.83	1.00	1.00	1.00	100	1.00	1.00	0.94	0.99	0.96	1.00	100	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	1.00	1.00	1.00	1.00	1.00	100	1.00	1.00	1.00	1.00	1.00	0.77	077	1.00	0.78	0.78	1.00	1.00	1.00	100	0.94	096	0.98
Netherlands	0.25	0.37	0.69	0.25	0.35	0.70	025	0.33	0.77	0.26	0.35	0.75	0.24	0.32	0.74	0.22	0.32	0.69	0.23	0.36	065	0.28	0.44	0.63	0.26	0.39	0.68	022	0.32	0.71	0.28	0.40	0.69	0.22	028	0.80	0.30	0.30	1.00	0.31	0.31	099	0.25	0.34	0.75
Austria	0.90	0.96	0.94	0.94	0.96	0.98	0.86	0.91	0.95	0.90	0.94	0.96	0.86	0.88	0.97	0.82	0.83	0.99	0.70	0.85	0.82	0.74	0.91	0.82	0.75	0.93	0.80	0.61	0.80	0.76	0.69	0.85	0.81	0.65	0.84	0.78	0.58	0.77	0.75	0.64	0.75	0.85	0.76	0.87	0.87
Portugal	0.78	0.78	1.00	0.80	0.80	1.00	0.88	0.88	1.00	0.68	0.68	1.00	0.82	0.82	1.00	0.77	0.77	1.00	0.85	0.85	100	0.94	0.94	1.00	0.43	0.43	1.00	0.44	0.44	1.00	0.56	0.56	1.00	0.73	073	1.00	0.66	0.66	1.00	0.79	0.79	100	0.72	072	1.00
Finland	0.98	0.98	1.00	0.92	0.92	1.00	0.86	0.86	1.00	0.93	0.93	1.00	0.81	081	1.00	0.79	0.79	1.00	0.76	0.76	100	0.86	0.86	1.00	0.97	0.97	1.00	0.84	0.84	1.00	0.83	0.83	1.00	0.75	0.78	0.96	0.74	0.74	1.00	0.51	0.51	100	0.82	0.83	1.00
Sweden	1.00	1.00	1.00	0.95	0.95	1.00	0.95	0.95	1.00	0.96	0.96	1.00	0.90	0.90	1.00	0.78	0.78	1.00	0.84	0.84	100	0.93	0.93	1.00	0.96	0.96	1.00	0.89	0.89	1.00	0.82	0.82	1.00	0.83	0.83	1.00	0.77	0.77	1.00	0.59	0.59	100	0.87	0.87	1.00
United Kingdom	0.52	0.52	1.00	0.37	0.37	1.00	0.44	0.44	1.00	0.45	0.45	1.00	0.37	0.37	1.00	0.31	0.31	1.00	0.31	0.31	100	0.36	0.36	1.00	0.47	0.47	1.00	0.37	0.37	1.00	0.39	0.49	0.78	0.37	0.37	1.00	0.41	0.41	1.00	0.41	0.45	091	0.40	0.41	0.98
Average By Year	0.62	0.75	0.82	0.64	0.76	0.83	064	0.75	0.84	0.62	0.73	0.83	0.64	075	0.84	0.62	0.72	0.84	0.62	0.73	082	0.66	0.78	0.82	0.62	0.72	0.84	0.58	0.65	0.84	0.61	0.72	0.82	0.59	071	0.82	0.61	0.72	0.84	0.63	0.74	085	0.62	073	0.83

Appendix C: Cost efficiency of bioenergy industry in developing countries over 1990-1999

Year	1990			1991			1992			1993			1994			1995			1996			1997			1998			1999			Average By Year		
Country	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE
Bulgaria	0.13	0.25	0.50	0.11	0.20	0.52	0.08	0.14	0.57	0.12	0.79	0.16	0.12	0.57	0.21	0.11	0.24	0.48	0.17	0.31	0.54	0.46	0.46	1.00	0.70	0.72	0.97	0.06	0.07	0.86	0.21	0.38	0.58
Czech	0.31	0.31	1.00	0.29	0.29	1.00	0.58	0.58	1.00	0.43	0.45	0.94	0.46	0.53	0.87	0.19	0.26	0.75	0.39	0.51	0.77	0.49	0.65	0.75	0.41	0.56	0.73	0.66	0.94	0.69	0.42	0.51	0.85
Estonia	0.11	0.39	0.29	0.12	0.42	0.28	0.17	0.32	0.53	0.19	0.34	0.55	0.28	0.52	0.53	0.20	0.25	0.82	0.38	0.38	1.00	0.40	0.43	0.93	0.24	0.29	0.82	0.34	0.41	0.85	0.24	0.37	0.66
Croatia	0.13	0.13	1.00	0.13	0.13	1.00	0.14	0.18	0.76	0.14	0.24	0.57	0.15	0.19	0.82	0.07	0.09	0.78	0.17	0.17	0.96	0.18	0.18	1.00	0.08	0.08	1.00	0.12	0.14	0.83	0.13	0.15	0.87
Cyprus	0.09	1.00	0.09	0.10	1.00	0.10	0.10	0.97	0.10	0.10	0.96	0.11	0.11	0.80	0.14	0.11	0.99	0.11	0.16	0.97	0.16	0.16	0.96	0.16	0.16	0.98	0.16	0.26	0.81	0.32	0.13	0.94	0.14
Latvia	0.29	0.29	1.00	0.31	0.31	1.00	0.36	0.40	0.90	0.39	0.46	0.85	0.45	0.45	1.00	0.30	0.33	0.91	0.41	0.47	0.87	0.35	0.43	0.79	0.16	0.17	0.97	0.20	0.20	1.00	0.32	0.35	0.93
Lithuania	0.12	0.22	0.55	0.12	0.22	0.56	0.13	0.26	0.52	0.18	0.25	0.73	0.19	0.24	0.79	0.10	0.10	1.00	0.18	0.19	0.94	0.15	0.18	0.86	0.08	0.09	0.82	0.11	0.11	1.00	0.14	0.19	0.78
Hungary	0.10	0.11	0.90	0.13	0.22	0.57	0.21	0.41	0.52	0.38	0.54	0.71	0.42	0.55	0.76	0.23	0.29	0.80	0.38	0.48	0.79	0.32	0.41	0.78	0.20	0.23	0.87	0.37	0.45	0.81	0.27	0.37	0.75
Malta	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poland	0.09	0.09	1.00	0.09	0.09	1.00	0.12	0.12	1.00	0.26	0.40	0.65	0.28	0.43	0.65	0.15	0.15	1.00	0.31	0.31	1.00	0.32	0.32	1.00	0.19	0.19	1.00	0.26	0.26	1.00	0.21	0.24	0.93
Romania	0.06	0.08	0.77	0.07	0.08	0.91	0.08	0.16	0.53	0.12	0.19	0.60	0.12	0.20	0.62	0.05	0.07	0.72	0.20	0.23	0.88	0.23	0.23	1.00	0.06	0.06	1.00	0.07	0.07	1.00	0.11	0.14	0.80
Slovenia	0.21	0.22	0.95	0.22	0.22	1.00	0.26	0.37	0.71	0.28	0.28	1.00	0.27	0.27	1.00	0.16	0.16	1.00	0.31	0.31	1.00	0.23	0.23	1.00	0.13	0.13	1.00	0.22	0.26	0.83	0.23	0.24	0.95
Slovakia	0.07	0.08	0.92	0.06	0.08	0.79	0.06	0.10	0.62	0.10	0.10	1.00	0.07	0.07	1.00	0.34	0.34	1.00	0.09	0.09	1.00	0.07	0.07	1.00	0.54	0.54	1.00	0.06	0.06	1.00	0.15	0.15	0.93
Average By Country	0.21	0.32	0.77	0.21	0.33	0.75	0.25	0.38	0.67	0.28	0.46	0.68	0.30	0.45	0.72	0.23	0.33	0.80	0.32	0.42	0.84	0.34	0.43	0.87	0.30	0.39	0.87	0.29	0.37	0.86	0.27	0.39	0.78

Appendix D: Cost efficiency of bioenergy industry in developed countries over 1990-1999

Year	1990			1991			1992			1993			1994			1995			1996			1997			1998			1999			Average By Country		
Country	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE	CE	AE	TE
Belgium	0.27	0.39	0.68	0.26	0.37	0.69	0.34	0.48	0.71	0.26	0.58	0.45	0.23	0.52	0.45	0.23	0.37	0.64	0.29	0.54	0.55	0.30	0.53	0.58	0.31	0.50	0.62	0.41	0.65	0.64	0.29	0.49	0.60
Denmark	0.34	0.63	0.53	0.35	0.66	0.54	0.43	0.79	0.54	0.45	0.90	0.50	0.46	0.88	0.53	0.42	0.81	0.52	0.46	0.84	0.54	0.46	0.85	0.55	0.46	0.80	0.57	0.48	0.84	0.57	0.43	0.80	0.54
Germany	0.51	0.95	0.54	0.50	0.95	0.53	0.53	0.93	0.57	0.56	0.95	0.59	0.58	0.95	0.61	0.55	0.92	0.60	0.59	0.95	0.62	0.64	0.91	0.70	0.65	0.91	0.71	0.68	0.92	0.74	0.58	0.93	0.62
Ireland	0.07	0.21	0.34	0.08	0.22	0.36	0.08	0.21	0.36	0.08	0.30	0.26	0.08	0.28	0.29	0.06	0.17	0.34	0.10	0.18	0.56	0.11	0.23	0.48	0.08	0.17	0.51	0.12	0.22	0.55	0.09	0.22	0.40
Greece	0.23	0.31	0.77	0.26	0.32	0.81	0.31	0.31	1.00	0.22	0.22	1.00	0.22	0.22	1.00	0.17	0.17	1.00	0.22	0.22	1.00	0.25	0.32	0.80	0.18	0.18	1.00	0.26	0.29	0.88	0.23	0.25	0.93
Spain	0.66	0.66	1.00	0.69	0.69	1.00	0.72	0.72	1.00	0.66	0.66	1.00	0.72	0.72	1.00	0.59	0.59	1.00	0.75	0.75	1.00	0.73	0.73	1.00	0.66	0.66	1.00	0.61	0.69	0.88	0.68	0.69	0.99
France	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	0.31	0.64	0.49	0.34	0.67	0.51	0.33	0.67	0.50	0.38	0.77	0.49	0.39	0.80	0.49	0.34	0.67	0.51	0.39	0.78	0.51	0.39	0.81	0.48	0.38	0.75	0.50	0.42	0.80	0.52	0.37	0.74	0.50
Luxembourg	0.54	0.93	0.58	0.56	0.93	0.61	0.37	0.74	0.50	0.69	0.98	0.71	0.70	0.98	0.72	0.59	1.00	0.60	0.75	0.99	0.76	0.85	0.97	0.88	0.70	0.95	0.74	0.94	0.99	0.95	0.67	0.94	0.70
Netherlands	0.19	0.34	0.55	0.21	0.39	0.54	0.28	0.52	0.53	0.26	0.55	0.47	0.28	0.58	0.49	0.28	0.53	0.52	0.24	0.39	0.63	0.25	0.38	0.67	0.27	0.40	0.68	0.26	0.35	0.75	0.25	0.44	0.58
Austria	0.62	0.68	0.90	0.61	0.75	0.81	0.80	0.91	0.88	0.81	0.98	0.83	0.72	0.97	0.75	0.62	0.83	0.75	0.73	0.96	0.76	0.76	0.92	0.83	0.73	0.90	0.81	0.87	0.97	0.89	0.72	0.89	0.82
Portugal	0.32	0.36	0.88	0.37	0.41	0.90	0.73	0.73	1.00	0.69	0.69	1.00	0.65	0.65	1.00	0.42	0.42	1.00	0.60	0.60	1.00	0.55	0.55	1.00	0.34	0.34	1.00	0.58	0.58	1.00	0.52	0.53	0.98
Finland	0.48	0.58	0.83	0.51	0.66	0.78	0.86	0.97	0.88	0.93	0.96	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.88	0.92	0.95
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.97	1.00	1.00	1.00	1.00	0.90	0.90	1.00	0.96	0.96	1.00	1.00	1.00	1.00	0.88	0.88	1.00	0.97	0.97	1.00
UK	0.31	0.60	0.52	0.32	0.59	0.54	0.47	0.68	0.70	0.46	0.66	0.69	0.54	0.59	0.92	0.49	0.50	0.96	0.59	0.59	1.00	0.60	0.60	1.00	0.50	0.50	1.00	0.50	0.50	1.00	0.48	0.58	0.83
Average By Year	0.46	0.62	0.71	0.47	0.64	0.71	0.55	0.71	0.75	0.56	0.75	0.73	0.57	0.74	0.75	0.52	0.66	0.76	0.57	0.71	0.79	0.59	0.72	0.80	0.55	0.67	0.81	0.60	0.71	0.82	0.54	0.69	0.76

Appendix E: Average of cost efficiency of bioenergy industry in EU Region over 1990-1999

Year	Efficiency	Average By Developing Country	Average By Developed Countries	Average By EU28 Countries
1990	CE	0.21	0.46	0.33
	AE	0.32	0.62	0.47
	TE	0.77	0.71	0.74
1991	CE	0.21	0.47	0.34
	AE	0.33	0.64	0.48
	TE	0.75	0.71	0.73
1992	CE	0.25	0.55	0.40
	AE	0.38	0.71	0.55
	TE	0.67	0.75	0.71
1993	CE	0.28	0.56	0.42
	AE	0.46	0.75	0.60
	TE	0.68	0.73	0.71
1994	CE	0.30	0.57	0.44
	AE	0.45	0.74	0.59
	TE	0.72	0.75	0.74
1995	CE	0.23	0.52	0.37
	AE	0.33	0.66	0.50
	TE	0.80	0.76	0.78
1996	CE	0.32	0.57	0.45
	AE	0.42	0.71	0.56
	TE	0.84	0.79	0.82
1997	CE	0.34	0.59	0.46
	AE	0.43	0.72	0.57
	TE	0.87	0.80	0.83
1998	CE	0.30	0.55	0.43
	AE	0.39	0.67	0.53
	TE	0.87	0.81	0.84
1999	CE	0.29	0.60	0.44
	AE	0.37	0.71	0.54
	TE	0.86	0.82	0.84
Average By Year	CE	0.27	0.54	0.41
	AE	0.39	0.69	0.54
	TE	0.78	0.76	0.77

Appendix F: Details of parametric and non-parametric mean tests during1990-1999

Detailed of Parametric and Non-Parametric Tests

		Parametric Test						Non-Parametric test											
		t-test						Mann Whitney Wilcoxon test						Kruskal Wallis					
Year	Group	CE	t	AE	t	TE	t	CE	Z	AE		TE	Z	CE	Chi-Square	AE	Chi-Square	TE	Chi-Square
1990	Developing	0.2085	-2.502	0.3208	-2.685	0.7669	0.581	9.5	-2.999	9.92	-2.746	16.15	-1.002	9.5	8.993	9.92	7.541	16.15	1.005
	Developed	0.4567	(0.019)**	0.6187	(0.013)**	0.7073	(0.567)	18.83	(0.003)***	18.47	(0.003)***	13.07	(0.316)	18.83	(0.003)***	18.47	(0.006)***	13.07	(0.316)
1991	Developing	0.2115	-2.643	0.3277	-2.858	0.7485	0.397	9.38	-3.066	9.38	-2.818	15.92	-0.867	9.38	9.402	9.81	7.944	15.92	0.752
	Developed	0.4707	(0.014)**	0.6407	(0.009)***	0.708	(0.695)	18.93	(0.002)***	18.93	(0.005)***	13.27	(0.386)	18.93	(0.002)***	18.57	(0.005)***	13.27	(0.386)
1992	Developing	0.2531	-2.857	0.3854	-3.114	0.6738	-0.756	9.77	-2.836	10.04	-2.674	13.73	-0.467	9.77	8.044	10.04	7.148	13.73	0.218
	Developed	0.55	(0.008)***	0.7107	(0.005)***	0.7447	(0.457)	18.6	(0.005)***	18.37	(0.005)***	15.17	(0.641)	18.6	(0.005)***	18.37	(0.008)***	15.17	(0.641)
1993	Developing	0.2838	-2.746	0.4615	-2.749	0.6823	-0.465	10.27	-2.538	10.5	-2.398	14.15	-0.21	10.27	6.44	10.5	5.749	14.15	0.044
	Developed	0.5633	(0.01)***	0.7467	(0.01)***	0.7313	(0.646)	18.17	(0.011)**	17.97	(0.016)**	14.8	(0.834)	18.17	(0.011)**	17.97	(0.016)**	14.8	(0.834)
1994	Developing	0.3015	-2.613	0.3015	-2.968	0.3015	-0.267	10.42	-2.445	10	-2.697	14.42	-0.047	10.42	5.979	10	7.276	14.42	0.002
	Developed	0.5693	(0.015)**	0.5693	(0.006)***	0.5693	(0.792)	18.03	(0.014)**	18.4	(0.007)***	14.57	(0.962)	18.03	(0.014)**	18.4	(0.007)***	14.57	(0.962)
1995	Developing	0.2315	-2.78	0.3285	-2.922	0.7977	0.370	9.65	-2.908	9.77	-2.841	15.27	-0.475	9.65	8.457	9.77	8.072	15.27	0.226
	Developed	0.5173	(0.010)***	0.6653	(0.007)***	0.7627	(0.715)	18.7	(0.004)***	18.6	(0.004)***	13.83	(0.635)	18.7	(0.004)***	18.6	(0.004)***	13.83	(0.635)
1996	Developing	0.3192	-2.605	0.4169	-2.775	0.8392	0.506	10.42	-2.445	10.54	-2.375	15.23	-0.456	10.42	5.977	10.54	5.64	15.23	0.208
	Developed	0.574	(0.015)**	0.7127	(0.010)***	0.7953	(0.10)	18.03	(0.014)**	17.93	(0.018)**	13.87	(0.648)	18.03	(0.014)**	17.93	(0.018)**	13.87	(0.648)
1997	Developing	0.3354	-2.549	0.4269	-2.762	0.8669	0.823	10.65	-2.306	10.54	-2.376	16.15	-1.044	10.65	5.317	10.54	5.647	16.15	1.09
	Developed	0.59	(0.017)**	0.7173	(0.017)**	0.798	(0.418)	17.83	(0.022)**	17.93	(0.032)**	13.07	(0.395)	17.83	(0.021)**	17.93	(0.017)**	13.07	(0.297)
1998	Developing	0.3038	-2.233	0.3877	-2.326	0.8723	0.761	10.69	-2.285	10.92	-2.146	15.85	-0.85	10.69	5.222	10.92	4.603	15.85	0.722
	Developed	0.5507	(0.034)**	0.6707	(0.029)**	0.8093	(0.454)	17.8	(0.022)**	17.6	(0.032)**	13.33	(0.395)	17.8	(0.022)**	17.6	(0.032)**	13.33	(0.395)
1999	Developing	0.2869	-2.977	0.3677	-2.944	0.8608	0.509	9.73	-2.862	10.15	-2.605	15.38	-0.547	9.73	8.193	10.15	6.785	15.38	0.299
	Developed	0.6007	(0.006)***	0.712	(0.007)***	0.8247	(0.615)	18.63	(0.004)***	18.27	(0.009)***	13.73	(0.585)	18.63	(0.004)***	18.27	(0.009)***	13.73	(0.585)

Note: ***, ** and * indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are P-values

Appendix G: Summary for developing and developed countries over 1990-1999

	Test groups (1990-1999)					
	Parametric test		Non-parametric test			
Individual test Hypothesis test	t-test		Mann–Whitney [Wilcoxon] test		Kruskall–Wallis test	
Test statistics	t (Prb> t)		z (Prb> z)		?? (Prb>??)	
	Mean	t	Mean rank	z	Mean rank	??
Cost Efficiency						
Developing Countires	0.399	-2.650	13.968	-2.660	13.968	7.202
Developed countries	0.419	(0.011)**	14.449	(0.010)**	14.449	(0.010)**
Allocative Efficiency						
Developing Countires	0.515	-2.810	13.998	-2.567	14.002	6.640
Developed countries	0.535	(0.011)**	14.437	(0.013)**	14.441	(0.012)**
Technical Efficiency						
Developing Countires	0.739	0.246	14.591	-0.597	14.591	0.457
Developed countries	0.742	(0.541)	14.464	(0.575)	14.464	(0.565)

Note (1): *** , ** and * indicate significance at the 1%, 5%, and 10% levels respectively Note (2): values in parentheses are p-value

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