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Analyzing the Greek renewable energy sector: A Data Envelopment Analysis approach

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ABSTRACT

This paper applies a bootstrapped Data Envelopment Analysis (DEA) formulation aiming to evaluate the financial performance of the firms operating in the Greek renewable energy sector. With the use of financial ratios in a DEA setting, efficiency ratios are constructed in order to analyse firms' financial performance. The results reveal that firms' performances are positively influenced by the high levels of return on assets and equity and by lower levels of debt to equity. In addition it appears that there are not significant differences of firms' efficiency levels indicating high competitiveness between firms. Finally, firms producing wind energy appear to perform better than firms producing hydropower energy. It emerges that the majority of firms are operating in the wind and hydropower energy production making the Greek market of solar energy production being an emerging segment of the Greek renewable energy sector.

Contents

1. Introduction

The increase in world population demands a successful implementation of sustainable development. Nowadays conventional energy sources satisfy the majority of the world energy demand. However renewable energy sources (like solar, hydropower, wind and biomass) are the main environmental friendly alternatives [1]. Changes towards more environmental friendly energy sources will not only deter environmental degradation but they are undepleted, more flexible, and give the possibility of decentralization [2]. As the world becomes more sensitive to environmental issues, countries with obsolete energy sectors, like Greece, will be forced to make radical changes.

The Kyoto protocol is a product of this environmental sensitivity. According to the protocol, countries must limit the growth of Greenhouse Gases (GHGs) to 25% and the production of renewable energy sources (hereafter RES) must be the 20% of the total energy production [3]. Agoris et al. [4] examine three different scenarios for three different energy policies under the Kyoto framework. They conclude that if the Greek government makes the proper investments, the Kyoto targets may be achieved for Greece.

Banõs et al. [5] suggest that governments and businesses strangle on the decision of whether or not to establish renewable energy systems in a given place, but they fail to decide which renewable energy source or combination of sources is the best for each place. Based on that dilemma Evans et al. [6] concluded that wind power can require more land and high relative capital costs but has the lowest relative greenhouse gas emissions and the least water consumption demands.[1]

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[1] For recent studies investigating the impact of renewable energy systems on Economics and the environment see also Hepbasli [7] and Varun Prakash and Bhatt [8].

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Several industry studies have shown the importance of renewable energy sources and especially for solar energy which can be viable alternative source of industrial energy. However according to Taibi et al. even though solar heating can reduce costs in industries, not much attention has been received from industry policy makers [9]. Moreover, Ibrahim [10] examined the Egyptian electricity market and found that solar and wind energy will be the main driving forces of Egypt's electricity generation. Trappey et al. [11] by applying systems dynamic models illustrated that for the case of the Taiwan Penghu island the dynamic effects of solar energy can be a viable solution to energy related problems also for other regions. Furthermore, for the case of India Sharma et al. [12] have found that renewable energy sources are the main solution to India's long-standing energy problems. Especially they claim that solar energy can increase energy security, reform and 'open' the renewable market and address India's environmental concerns.

However the adoption and implementation of RES is not a straightforward scenario for some countries. Hamed Abu et al. [13] suggest that due to different conditions (infrastructural, political, social, geographical, economic and environmental) of the Palestinian Territories it is very difficult to use RES which in turn could replace more than 25% of the current demand of the Palestinian energy.

Furthermore, in the case of Greece Kaldellis et al. [14] argue that the final cost of locally produced water from RES in Greek islands is significantly lower than the cost of transferred water. Doukas et al. [15] investigate the sustainable electricity technologies in Greece and find that from environmental friendly energy sources, wind and biomass are of extreme interest. According to Diakoulaki and Karangelis [16] higher penetration of renewable energy sources is the best compromised configuration for the Greek power generation sector.

Diachronically, Greek electricity market is controlled either directly or indirectly by the state. A thorough historical background of Greek electricity sector is presented by Illiadou [17]. According to the author, at 1950 the state merged the small scattered local electricity enterprises into a large national company, the Public Power Corporation (PPC), which was a 100% public corporation. PPC was a monopoly as the Greek national law forbade any private energy enterprise. At 1994, private individuals were allowed for first time to produce power but only for their own use, for cogeneration with PPC and for RES. They were also obliged to sell to PPC the excessive amount of energy which they did not consume.

During the last decade, legal efforts have been made in order to comply with EU legislation and liberalize the energy market. Despite the efforts, PPC is still under public control and continues to possess almost the entire market of electricity production and provision. According to Illiadou [17], two significant issues of the Greek energy sector are the under-investment and the inability to produce power with modern techniques which are more efficient and less costly.

Within the EU, as the Greek energy sector is responsible for the majority of total CO_2 emissions, Greece must increase the restriction for GHG up to 25% between 2008 and 2012 [18]. As mentioned, the Greek electricity sector is obsolete. In 1999, 89.1% of the electricity was produced by fossil fuels, while from more friendly to the environment energy sources, only hydropower is worth mentioning with a 10.1% [19]. In mainland Greece, the situation is slightly better as the production of hydropower was 27% of the total energy production but on islands 93% of the total production came from heavy or light fuel oil [20].

On the consumption side, in 2006 68.5% of the final energy consumption came from oil and 21% from electricity, while only 5.2% came from RES [21]. Another interest aspect is that the vast majority of hydropower stations and wind power installations belong to PPC [19]. Many authors point out that the Greek electricity sector needs radical reform. Hondroyiannis et al. [22] study the relationship between energy consumption and economic growth over the period 1960–1996 and find that there is a strong relationship between them. Furthermore, they claim that structural changes in the Greek electricity sector will lead to rapid economic growth and that economic growth will lead to cleaner energy sources. Their results are in line with previous studies like Samouilidis and Mitropoulos [23], which indicate that structural changes are needed in the Greek electricity sector.

Based on these lines this paper by applying Data Envelopment Analysis (DEA) alongside with bootstrap techniques, analyses for the first time the Greek renewable energy sector by using financial data of 78 firms (this sample includes all the main/largest companies) operating in that sector for the period 2006–2008.

2. The theoretical background for measuring firms' financial performance

The assessment of a business unit's efficiency has attracted the interest worldwide. A simple approach to measure the efficiency is by using financial ratios which permit comparison of decision making units (DMUs) of different sizes [24]. A major drawback of this approach is that a single financial ratio does not incorporate every aspect of a unit's efficiency and thus it is not a sufficient measure. Moreover, if we examine more than one financial ratio, everyone is compared with a benchmark which is not similar for every single financial ratio. For example, if we examine the efficiency of a group of firms based on return on assets (ROA) and return on equity (ROE) it is possible that a firm which is marked as a benchmark based on ROA is not a benchmark based on ROE. Furthermore, when one makes the comparison based on a single financial ratio then it is assumed that every other factor is constant, which is a simplification of the truth [25].

In order to overcome those problems, an aggregation of financial ratios is necessary. Financial ratio analysis weights a number of single financial ratios into one combined ratio [26]. According to Yeh [25], aggregation of single financial ratios is not an easy task because of the changing economic conditions. The subjectivity of the aggregation is a significant disadvantage of this approach as it is based on imagination and experienced judgment [27]. Financial ratio analysis is used widely across the literature, applied in various sectors like banking [28], healthcare [29] and for business firms in general [30,31]. In other approaches, authors incorporate financial ratios in several analytical settings such as regression analysis [32], multi-discriminant models [33] and logistic and probabilistic regressions [34,35].

Berger and Humphrey [36] investigate a large number of studies and argue that frontier analysis is preferred to traditional ratio analysis as it determines objectively an overall efficiency value and provides a ranking for the units under assessment. There are two main frontier approaches, parametric and non-parametric analysis. Each of them has one significant disadvantage. Parametric analysis requires specification of the functional form while non-parametric analysis does not allow for an error term. The most remarkable non-parametric approach is the Data Envelopment Analysis applied in various sectors.

Traditionally, DEA uses absolute numbers as variables however in a number of special cases uses ratios instead [37]. These special cases may involve the nature of the accessible data or the need for a proper reflection of the production function. Emrouznejad and Amin [38] argue that standard DEA approach with ratios used as inputs or outputs may lead to incorrect result. The authors suggest a number of alternative DEA models in order to address the problem.

The sector with the majority of studies in the field is probably the banking sector. Yeh [25] investigates the efficiency of six banks in Taiwan over the period 1981–1989. A DEA model is adopted with