European Journal of Human Movement, 2019: **43**, 145-166

EVALUATING THE EMERGENCE OF ELITE PROFESSIONAL GOLFERS IN EUROPE WITH DATA ENVELOPMENT ANALYSIS

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ABSTRACT

The national golf organizations support the development of golf in their country and one of the signs of their success is the generation of elite professional golfers. In this paper, we analyze the emergence of elite professional golfers in eighteen European nations. The efficiency of these nations is measured through output-oriented Data Envelopment Analysis models. In particular, we propose variable and constant returns to scale radial models. The main purpose is to classify each of the nations as efficient or inefficient according to its ability to produce elite professional players and with regard to the inefficient ones, determine how far they have to go to achieve efficiency. We further propose a stepwise procedure for each inefficient nation that identifies a path towards the frontier with several intermediate points. The analysis of the results can be used by the nations for designing new strategies in order to improve their performance.

Keywords: data envelopment analysis, efficiency, CRS/VRS output oriented model, golfers.

EVALUANDO LA APARICIÓN DE GOLFISTAS PROFESIONALES DE ÉLITE EN EUROPA CON EL ANÁLISIS ENVOLVENTE DE DATOS

RESUMEN

Las organizaciones nacionales de golf apoyan el desarrollo del golf en cada país, un signo de su éxito es la proliferación de jugadores de golf profesionales. En este artículo analizamos la aparición de jugadores de élite profesionales del golf en dieciocho países europeos. La eficiencia de esas naciones es medida mediante un modelo de análisis envolvente de datos orientado al *"output"*. La principal contribución del trabajo es la clasificación de cada nación como eficiente o ineficiente de acuerdo a su habilidad para producir jugadores de élite profesionales. Respecto a las naciones ineficientes, se determina cómo de lejos están de la eficiencia y se propone el camino de cada nación a la frontera de la eficiencia. El análisis de los resultados puede ser usado por las organizaciones nacionales para determinar nuevas estrategias con el objetivo de mejorar su rendimiento respecto a la generación de golfistas profesionales.

Palabras clave: análisis envolvente de datos, CRS/VRS, modelo orientado al output, golfistas.

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Submitted: 22/03/2019 *Accepted:* 08/10/2019

INTRODUCTION

Golf is one of the most practiced amateur sports in the world and also one of the most important professional sports due to the great economic impact of elite professional tournaments.

There are two organizations that govern golf in the world, Royal and Ancient Golf of St. Andrews (R&A, 2015b) and the United States Golf Association (USGA, 2015), operating in separate jurisdictions and sharing a commitment to a single code for the Rules of Golf, 'Rules of Amateur Status and Equipment Standards'.

There are also organizations in each country (called Unions, Federations, European National Amateur Golf Associations …) that organize golf at the country level. In Europe, these organizations belong to the European Golf Association (EGA) that was founded in 1937. This Association solely concerns itself with matters of an international character and among its principal activities are arranging and co-coordinating both amateur and professional tournaments and International Matches (Championship and Professional Technical Committees), the set-up and management of the EGA Handicap System and maintaining an information center for its member federations to answer questions on various aspects of golf, such as classifying technical issues or evaluating statistics (EGA, 2015). For these national organizations it is very important to produce elite professional golfers that represent their country on world golf tours, because the more elite golfers a country has, the better it is known and considered at a worldwide level.

In this article, we propose the use of Data Envelopment Analysis (DEA) to carry out research on the relative efficiency of the emergence of elite professional golfers in Europe. DEA, as introduced in Charnes, Cooper, and Rhodes (1978), is a methodology for the analysis of the relative efficiency of ''decision-making units'' (DMUs) involved in a certain process. For each DMU it provides an efficiency score that assesses the relative efficiency of its performance in the use of several inputs to produce several outputs. DEA has been successfully used in many real applications, analyzing the efficiency of hospitals, airlines, universities, financial institutions, municipalities, countries, and so on (Ruiz, Pastor & Pastor, 2013).

We assess the emergence of elite professional golfers in a set of European nations, which play the role of DMUs. As for the variables to be used, the golf players in the European Tour and the golfers in the Race to Dubai are considered as outputs, and the number of golf courses, the number of golfers and the GDP in each country as inputs.

On its official website, the PGA European Tour (2015) reports the name and nationality of the elite professional golfers that have enrolled on the European Tour as well as the subset of those who have qualified for the Race to

Dubai. The Race to Dubai is the ranking of players that determines the best ones at the end of the season, which compete in the Dubai World Championship. In addition, we can ascertain the number of golf courses and golfers in each country from the EGA official website, variables that we consider essential to evaluate the importance of golf in each country. Finally, we obtain some general information about each country that may influence the raising of elite professional golfers, taking into account different perspectives: population (or potential candidates), gross domestic product (GDP) and the number of existing golf courses (or potential space).

To measure relative efficiency, DEA uses an empirical technology of reference, which is constructed from the data by assuming some conditions. This technology is defined through a set of different nation characteristics that is used as reference in the assessment of the performance of each nation. Thus, the assessment of efficiency in DEA is based on a benchmarking analysis: The different countries are classified into efficient or inefficient, so the latter are assessed with reference to a best practice frontier determined by the former. In particular, for each inefficient nation, DEA determines an efficient country of reference, whether real or virtual (i.e. a linear combination of real countries), which can be used for benchmarking. To be specific, the coordinates of this benchmark represent an efficient target, which is used as a role model for the nation being evaluated. Therefore, comparing actual data and target, allows the analyst to identify the sources of inefficiency and quantify it, and this information is used to suggest possible directions for improvement.

Respect to the impact of golf in European society, in 2014, according to R&A (2015a), there were 34,011 golf courses in 206 countries around the world and more than 60 million players. Most of the worldwide offer of golf courses is in the Western Hemisphere. America leads the world supply with 55% of the number of courses, where 45% of the facilities correspond to the U.S.A., while Europe has the second largest offer with 22%, followed by Asia with 14% and Oceania with 6%.

In Europe, there has been such a spectacular development of golf as a sporting activity that has led, at the end of 2014, to there being over 4.2 million players and 7,020 golf courses. From 1990 to 2010, there was a constant growth in the number of golf courses and players in Europe, with an average annual increase of 4.6% and 7.2%, respectively; but in the 2010-2014 period there was a decrease in the number of players by 0.21% and a growth in the number of golf courses by 4.1%. Around 75% of fields and players from all over Europe are concentrated in only six countries (England, Germany, France, Sweden, Ireland and Spain). The European countries that have the largest number of courses and the largest number of players are in the center and north of the continent. In general, these countries have enough golf courses to meet their demand and, in some cases as in the United Kingdom, the number of golf courses currently exceeds demand (EGU, 2004). However, the main problem faced by players in these countries is the climate, which causes a strong seasonality in the use and enjoyment of their courses. On the other hand, southern European countries, mainly Spain and Portugal, have ideal climatic conditions for the practice of golf throughout the year, which attracts players from central and northern Europe through golf tourism (Del Campo, Molina, & Sales, 2006).

DEA has been successfully used in many real-world applications both in public and in private sectors and, in particular, it has been used in the context of different sports, for example: baseball (Einolf, 2004; Lin & Chen, 2015), basketball (Bolen, Rezek, & Pitts, 2017; Chen, Gong , & Li, 2017), tennis (Chitnis & Vaidya, 2014), handball (Gutierrez & Ruiz, 2013), soccer (Carmichael & Thomas, 2008; Espitia-Escuer & Garcia-Cebrian, 2008; Guzman, 2006; Haas, 2003; Pestana, Assaf, & Sa-Earp, 2010; Zambon-Ferraresi, Garcia-Cebrian, Lera-Lopez, & Iraizoz, 2015) or cricket (Amin & Sharma, 2012), to mention just a few.

In the context of golf, DEA has been used in some papers. Fried, Lambrinos, & Tyner (2004) used DEA to evaluate the performance of golfers, based on two indices obtained for the golfers (a performance under pressure index and an athletic ability performance index) on the three elite professional golf tours in the USA (Professional Golf Association, Ladies Professional Golf Association and Senior Professional Golf Association). Later, Fried & Tauer (2011) applied DEA to analyze the aging and the ability to perform under pressure on the PGA Tour.

Some works have been developed in relation to using DEA for evaluating the relative efficiency of sports at a country level. Lozano, Villa, Guerrero, & Cortes (2002) used DEA to measure the performance of nations participating at five Summer Olympic Games with two inputs (GDP and population) and three outputs (number of gold, silver and bronze medals won). Using the same inputs and outputs, Zhang, Li, Meng, & Liu (2009) used DEA to measure the performance of nations at the Athens 2004 Olympics with Lexicographic preferences and Wu, Zhou, & Liang (2010) used a DEA model to measure the performance of each country at the 2008 Beijing Summer Olympic Games. Mello, Angulo-Meza y Gomes (2012) analyzed whether the number of athletes competing for each country accords with the number of medals won. Finally, Pastor, Del Campo, Vidal, Pastor, & Agullo (2015) applied DEA models for evaluating the efficiency of golf tourism at the country level (Mediterranean countries), using cyber metric variables that are easy to obtain with an Internet browser.

Finally, Barros (2006) used DEA for the evaluation of Portuguese sport federations and the rationalization of their training activities. He found that the government subsidies received by sport federations did not result in an increasing of technical efficiency of those sport federations which implemented sport training programs.

The purpose of this article is to analyze the relative efficiency of European countries to produce elite professional golf players. We have used different DEA models which may provide useful information to golf organizations in each country for improving the performance of their elite professional golfers. Nevertheless, in this article we also raise a number of questions for future research, which open the door to the use of some of the extensions and enhancements of the basic DEA methodology to address them.

The paper unfolds as follows. In Section 2, we present the main aspects of the methodology employed to evaluate the emergence of professional golf players in Europe. Section 3 presents the data employed in our analysis, the analysis carried out, and a discussion of the results obtained, while Section 4 presents our conclusions.

METHOD

In order to evaluate a nation´s ability for raising elite golf players in Europe we resort to efficiency models, basically, linear programming models. We are going to analyze the efficiency of a given set of European nations resorting to a number of inputs, which are determinant to explain the different outputs. The variables considered are the following:

1) GDP: Gross domestic product. A variable that provides each nation´s GDP in billions of dollars. It represents the nation´s wealth. It was selected due to the presumption that the wealthier a nation is, the greater is its possibility for dedicating resources to sports in general and golf in particular.
2) Golf courses (GC): A variable that includes the number of golf courses available in each nation.
3) Golf players (GP): A variable that includes the number of affiliated golf players, with a license, in each nation.
4) Golf Pro European Tour (GPET): A variable that includes the number of all golf players that have been affiliated at the European Tour in each nation until 2014 (included).
5) Golf Pro Race to Dubai (GPRTD): A variable that includes the number of affiliated golf players who qualified for the Race to Dubai in each nation in 2014.
6) Population: A variable that indicates each nation´s population expressed in millions. This variable is chosen under the assumption that the more populated a nation is, the the greater the number of golf players it will have.

7) Surface: A variable that indicates the nation´s area, expressed in thousands of square kilometers. It represents the nation´s physical size. It has been chosen because larger regions usually offer a higher number of golf courses.

Variables (6) and (7) are considered auxiliary variables and are used to derive the ratio variables, which are employed in some of the DEA models solved.

We have only considered the nations for which the number of golf courses is, at least 50, and the number of national golf players at least 50,000. We have selected the biggest sample of European nations with these characteristics, 18, and for each of them we have collected the data summarized in Table 1.

TABLE 1
Dataset corresponding to 18 European nations (2014), alphabetical order.

	Variables					Auxiliary variables	
NATION	**GDP** (billion $	**Golf courses** (GC)	**Golf players** (GP)	**Golf pro european tour** (GPET)	**Golf pro race to dubai** (GPRTD)	**population** (million)	**Surface** thousand km²)
Austria	436.3	156	103.225	86	5	8.53	83.87
Belgium	533.4	84	60.867	84	4	11.23	30.53
Czech Rep.	205.5	102	56.438	51	0	10.51	78.87
Denmark	342.0	188	150.699	176	12	5.64	43.09
England	2.680.0	1.849	678.372	2.089	60	53.86	130.39
Finland	270.7	129	142.757	89	4	5.46	338.42
France	2.829.0	597	408.388	474	21	66.21	549.08
Germany	3.853.0	728	639.137	261	6	80.89	357.14
Ireland*	283.7	413	194.151	250	9	6.41	84.12
Italy	2.144.0	275	91.713	258	10	61.34	301.34
Netherlands	869.5	201	387.429	122	6	16.85	41.50
Norway	500.1	165	102.007	64	1	5.13	385.17
Portugal	229.6	86	14.094	88	4	10.40	92.21
Scotland	240.9	545	199.764	363	18	5.23	78.77
Spain	1.404.0	348	280.712	439	24	46.40	505.60
Sweden	570.6	448	474.777	537	24	9.69	450.30
Switzerland	685.4	96	88.523	81	3	8.19	41.28
Wales	47.3	151	49.084	162	5	3.08	20.77

**Includes Northern Ireland*

The data in Table 1 correspond to 2014: The number of golf courses and golf players were obtained from the European Golf Association, and the two remaining golf variables, the number of professional golf players playing at the European Tour and the number of the subset of players who finally qualified for the Race to Dubai, were obtained directly from the European Tour Website.

Finally, variables related to characteristics of the nation, such as Gross Domestic Product (GDP), expressed in billions of dollars, surface, expressed in thousands of square kilometers and population, expressed in millions of inhabitants were obtained from Eurostat and from the World Bank (2015).

As the size of our sample is reduced, to study the efficiency of the different nations we need to use a reduced set of variables and we have to determine which of them form the set of inputs, or resources, that explain the rise of the set of outputs, or goods. Obviously, the selection of the variables determines the results of the analysis. In previous golf study, Golf Courses and Golf players were used to study the relevance of golf in tourism (Pastor, et al. 2015). Moreover, another work about Tourism has taken into account the population, the GDP and the country size to analyze the efficiency (Pastor, Del Campo, Vidal & Pastor 2014). To analyze the impact of country golf relevance to produce elite players, information about elite players were absolutely relevant, and GPET and GPRTD were the clearest rankings of professional players.

Based on the previous variables, we have initially formulated two DEA models. Since the size of the nations that form the sample is very different, we have first considered a variable return to scale (VRS) model. Although there are different VRS DEA models available, we have chosen the BCC model proposed by Banker, Charnes & Cooper (1984), which is a radial model with two possible orientations: input and output. The first possibility, input-oriented (IO), means that we want to proportionally reduce all inputs without modifying the level of the outputs. On the other hand, output-oriented (OO) means that we want to expand radially all outputs without modifying the level of inputs. The characteristics of the inputs and outputs considered in the model tell us which orientation to use. In our case, we have chosen output-oriented, given that the inputs considered are non-discretionary variables.

Let us now consider the formulation of the envelopment form of the BCC-OO model:

$$
\begin{aligned}
&Max\ \Phi \\
&s.t. \\
&\sum_{j \in E} \lambda_j x_{ij} \le x_{i0}, \qquad i = 1, \ldots, m \\
&\sum_{j \in E} \lambda_j y_{rj} \ge \Phi y_{r0}, \qquad r = 1, \ldots, s \\
&\sum_{j \in E} \lambda_j = 1 \\
&\lambda_j \ge 0, \qquad j = 1, \ldots, n
\end{aligned}
$$

The previous formulation represents a model where we have *n* units to be evaluated (nations in our case), *m* inputs and *s* outputs. X_{ij} are constants representing the value of the input *i* of unit *j*, and Y_{rj} the value of output *r* of unit *j*. Set E represents the subset of strongly efficient points, obtained after preprocessing, which consists of solving the VRS additive model to identify these points, the Pareto-efficient points (Ali & Seiford, 1993). The variables of the model, λ_j, represent weights and are called *intensities*. As it is well known, Φ represents the efficiency score and is a number equal or greater than 1. A score of 1 means that the analyzed unit, nation in this case, is efficient. The higher the score, the more inefficient. It is a robust model and the scores attached to each nation are easy to understand and compare.

However, we have considered a second model in order to verify that, effectively, as we suspected, the size of the different nations is relevant. For this purpose, we have employed a constant return to scale (CRS) model. In particular, we have chosen the model proposed by Charnes, Cooper, & Rhodes (CCR) (1978). It also permits both orientations, input and output and the variables we have used recommend the output-oriented version.

Let us now consider the formulation of the envelopment form of the CCR-OO model:

$$
\begin{aligned}
&Max\ \Phi\\
&s.t.\\
&\sum_{j\in E}\lambda_j x_{ij} \le x_{i0}, \qquad i=1,\dots,m\\
&\sum_{j\in E}\lambda_j y_{rj} \ge \Phi y_{r0}, \qquad r=1,\dots,s\\
&\lambda_j \ge 0, \qquad j=1,\dots,n
\end{aligned}
$$

As in the BCC-OO model, we have performed pre-processing, solving the CRS additive model to identify the subset of nations which are strongly efficient, conforming the set E. Φ represents the efficiency score and is a number equal or greater than 1. An efficient unit scores 1 and the higher the value of Φ, the more inefficient. The previous models need to be solved once for each nation. So, in this case we need to solve each of the previous models eighteen times.

In both models, we have chosen 3 inputs and 2 outputs and we have worked with the raw data. A description of the models is given below:

(1) Model M_1
Type: BCC-OO
Sample: 18 nations
Variables: 3 inputs (GC, GP, GDP),
2 outputs (GPET, GPRTD)

(2) Model M_2

Type: CCR-OO
Sample: 18 nations
Variables: 3 inputs (GC, GP, GDP),
2 outputs (GPET, GPRTD)

In order to evaluate the robustness of the results given by the previous models, we have performed some additional analysis, explained below.

First, we want to analyze the scale efficiency that models M_1 and M_2, both employing raw data, report and compare it with the scale efficiency given by the models using derived variables, namely, ratios. Therefore, we need to develop two additional models, M_3 and M_4, which are the ratio versions of models M_1 and M_2, respectively. To calculate these derived variables, we have employed the auxiliary variables given in Table 1, as described below:

(3) Model M_3
Type: BCC-OO
Sample: 18 nations
Variables: 3 inputs (GC/Surface, GP/Population, GDP/Population),
2 outputs (GPET/Population, GPRTD/Population)

(4) Model M_4
Type: CCR-OO
Sample: 18 nations
Variables: 3 inputs (GC/Surface, GP/Population, GDP/Population),
2 outputs (GPET/Population, GPRTD/Population)

The scale efficiency score of a nation indicates whether a nation operates at the most productive scale size (score equals 1) or not. If a nation is scale-efficient, it means that any modifications on its size will render the unit less efficient according to its ability to generate quality golf players. A score lower than one indicates that nation is not well-dimensioned. The scale efficiency of a model is calculated as the average scale efficiency of the set of nations in the sample. For each one of the nations, the scale efficiency, in our case, is obtained by dividing the efficiency score obtained with variable return to scale technology by the efficiency using constant return to scale.

Finally, as the results, which are presented and discussed in detail in the next section, indicate that models M_1 and M_2 are appropriated, we would like to add an additional analysis to verify the robustness of the results given by these models. We have reduced the number of variables, decreasing the number of outputs from 2 to 1 as described below:

(5) Model M_5
Type: BCC-OO
Sample: 18 nations

Variables: 3 inputs (GC, GP, GDP),
1 output (GPET)

(6) Model M_6
Type: CCR-OO
Sample: 18 nations
Variables: 3 inputs (GC, GP, GDP),
1 output (GPET)

If the results given by these models are similar to those of the models with 2 outputs, we could decide to reduce the number of variables, simplifying the model and pointing out the relevant variables of our analysis.

Other DEA methods should be used in this analysis, for example, stochastic methods have been used to analyze Economics in the summer Olympics (Rathke & Woitek 2008; del Corral, Gomez-Gonzalez, Sanchez-Santos 2017). And other inputs and outputs have been used in this kind of studies, like climate to analyze sports performance in Africa (Manuel-Luiz & Fadal 2011). But the authors decide to use the BBC model as in previous articles (Pastor et al. 2014).

RESULTS

Table 2 shows the results obtained after solving M_1 for each one of the eighteen nations. We report the efficiency score of each nation and the optimal lambda values, which identify, as we will describe later, the final projections. In Column 2, we present the efficiency score for each nation, which represents the ability of each nation to generate professional golf players for the European Tour and the Race to Dubai. Columns 3 to 10 show the value of the λ variables in each of the eighteen models solved. The results indicate that eight of the eighteen nations have been rated as efficient: Belgium, Denmark, England, Portugal, Scotland, Spain, Sweden and Wales. This means that these nations cannot increase the number of professional players playing the European Tour or the Race to Dubai without modifying the value of their inputs: number of golf courses, number of golf players or GDP. These nations are employing adequate strategies in order to generate qualified golf players. The rest of the nations are inefficient, i.e. they could improve the quality of their professional golf players with better strategies without increasing the number of GC, GP or GDP. However, the efficiency scores indicate that the degree of inefficiency is somewhat different among them. The score obtained by Germany, 3.28, indicates that this is the most inefficient nation, followed by Norway with a score of 2.99. On the other hand, Italy and Switzerland are the less inefficient nations with scores of 1.05 and 1.25 respectively.

TABLE 2
Results for M1: a BCC-OO model with 3 inputs, 2 outputs, raw data.

Nation	Efficiency score (Φ)	λ_{BEL}	λ_{DEN}	λ_{ENG}	λ_{POR}	λ_{SCO}	λ_{SPA}	λ_{SWE}	λ_{WAL}
Austria	1.89	0.09	0.4	0	0.4	0	0.11	0	0
Belgium	**1.00**	**1**	0	0	0	0	0	0	0
Czech Rep.	2.09	0	0	0	0.79	0	0.01	0	0.2
Denmark	**1.00**	0	**1**	0	0	0	0	0	0
England	**1.00**	0	0	**1**	0	0	0	0	0
Finland	1.59	0	0	0	0.86	0	0.01	0.11	0.02
France	1.43	0	0	0.17	0	0	0.83	0	0
Germany	3.28	0	0	0.25	0	0	0.75	0	0
Ireland*	1.44	0	0	0.03	0	0.43	0	0.15	0.4
Italy	1.05	0	0	0.1	0.86	0	0.04	0	0
Netherlands	1.98	0	0	0	0.56	0	0.44	0	0
Norway	2.99	0	0	0	0.57	0	0.26	0	0.18
Portugal	**1.00**	0	0	0	**1**	0	0	0	0
Scotland	**1.00**	0	0	0	0	**1**	0	0	0
Spain	**1.00**	0	0	0	0	0	**1**	0	0
Sweden	**1.00**	0	0	0	0	0	0	**1**	0
Switzerland	1.25	0	0	0	0.96	0	0.04	0	0
Wales	**1.00**	0	0	0	0	0	0	0	**1**
	Sum	**1.09**	**1.4**	**1.55**	**6**	**1.43**	**3.49**	**1.26**	**1.8**

**Includes Northern Ireland*

The benchmarking analysis provided by DEA is one of the key features of this methodology. The λs give us information about which of the efficient nations act as role models in the assessments of the inefficient nations. Obviously, the higher the value of λ, the larger the role of the corresponding benchmark efficient nation. These values are also called intensities. The intensities presented in Table 2 have been rounded to two decimal points for reasons of clarity. These intensities can be used to identify, for an inefficient nation, the role models that can be used for the design of new golf strategies in order to improve its performance. As the number of efficient nations is high, we have performed additional processing in order to identify if any of these efficient points can be represented as a linear combination of some other efficient points. These points could be eliminated as role models in order to reduce the number of nations considered as benchmarks. However, all the efficient points are extreme efficient points. Therefore, we cannot eliminate any of them.

For example, in the case of Germany, rated as inefficient, two nations, England and Spain have acted as benchmarks in its valuation. In this case, the role of Spain (λ_{SPA}=0.75) is much more relevant than the role of England (λ_{ENG}=0.25). Therefore, Germany could develop similar strategies than those employed by Spain, and, to a lesser extent England to improve the number of top golf players. Italy or Finland should look at the plans carried out, mainly by Portugal, to increase the number of professional golf players that qualify for the European Tour and the Race to Dubai. We can observe that Portugal and Spain have played a relevant role as benchmarks in the analysis of the relative inefficient units. On the other hand, Belgium, Denmark and Sweden are less relevant role models. Therefore, the results indicate that the strategies employed by Portugal and Spain are adequate and can be considered by the inefficient nations in order to become efficient.

It should be interesting in inefficient countries to analyze the policies and strategies of efficient countries respect to golf courses, golf promotion and maybe competitive promotion of efficient countries. Spain and Portugal are relevant role models, but the weather is something that countries must take into account, looking for policies of countries with similar environmental circumstances. As there are efficient countries with really different weather, probably is more important the national golf promotion strategies than the climate conditions.

In order to compare all the nations on an equal footing, we have solved M_2, which is a CCR-OO model that exhibits constant return to scale. The results are presented in Table 3, where column 2 shows the score of efficiency derived from the model and columns 3 to 7 the value of the λ variables. The efficiency scores indicate that the set of inefficient nations is made up of twelve nations, with Germany and Norway being clearly the most inefficient. On the opposite side, Scotland and Italy have been rated as the less inefficient of this set. As in the previous case, we have determined that all the efficient nations are extreme efficient points and therefore we cannot reduce the set of nations to act as role models.

We can observe that Spain is efficient and highly relevant in the assessments of the nations rated as inefficient. It acts as a benchmark for all the inefficient nations, except for Scotland. Germany, the most inefficient nation with a score of 3.52 could imitate some of the schemes employed by Spain to generate better golf players.

If we compare the results given by models M_1 and M_2, we can observe that only two nations rated as efficient by the BCC model are classified as inefficient by the CCR model. These nations are Belgium and Scotland, although the latter is relatively near the efficiency, with a score near to 1. In the first model, Portugal and Spain are the efficient nations which play the most important role in the assessment of the inefficient nations, and in the second, Spain. The results of the BCC model show that Portugal participates as a benchmark for 7 nations and Spain as a benchmark for 9. The role of Spain is even more important in the results presented by the CCR model, acting as a referent of all the inefficient nations, except for Scotland.

TABLE 3
Results for M2: a CCR-OO model with 3 inputs, 2 outputs, raw data.

Nation	Efficiency score (Φ)	λ_{DEN}	λ_{ENG}	λ_{POR}	λ_{SPA}	λ_{SWE}	λ_{WAL}
Austria	1.93	0.35	0	0.40	0.16	0	0
Belgium	1.24	0	0.01	0	0.20	0	0
Czech Rep.	2.34	0.04	0	0	0.07	0.03	0
Denmark	**1.00**	1	0	0	0	0	0
England	**1.00**	0	1	0	0	0	0
Finland	1.77	0	0	0	0.11	0.20	0
France	1.54	0	0.09	0	1.24	0	0
Germany	3.52	0	0	0	2.10	0	0
Ireland*	1.80	0.14	0	0	0.05	0.12	2.10
Italy	1.17	0	0.07	1.34	0.09	0	0
Netherlands	2.08	0	0	0	0.58	0	0
Norway	3.11	0	0.04	0	0.27	0	0
Portugal	**1.00**	0	0	1	0	0	0
Scotland	1.08	0.24	0	0	0	0	3.30
Spain	**1.00**	0	0	0	1	0	0
Sweden	**1.00**	0	0	0	0	1	0
Switzerland	1.50	0	0	0	0.28	0	0
Wales	**1.00**	0	0	0	0	0	1
	Sum	**1.77**	**1.21**	**2.74**	**6.15**	**1.35**	**6.4**

**Includes Northern Ireland*

Next, we are going to check the scale efficiency reported by models M_1 and M_2, with raw data and compare it with that given by their ratio-variables version. The results are shown in Tables 4 and 5. Table 4 shows the scale efficiency scores for the models with raw data and Table 5 reports the scale efficiency scores for the models using the derived variables. A nation rated as efficient by the CCR model will always be scale efficient. In Table 4, we can observe two nations, Scotland and Belgium, rated as efficient by the BCC model that are not scale efficient.

The results indicate an average scale efficiency of 0.9 with raw data and a lower value, 0.79 when the ratio-variables are used. Although the difference is small, these results exhibit a better concordance between the BCC and the CCR models with the original variables than when we use the derived ratio-variables. Therefore, our proposal is to maintain our initial variables instead of using derived variables.

TABLE 4
Scale efficiency: Raw data model.

Country	Raw data models		
	BCC-Eff. (M_1)	CCR-Eff. (M_2)	Scale Eff.
Denmark	1,00	1,00	1,00
England	1,00	1,00	1,00
Portugal	1,00	1,00	1,00
Spain	1,00	1,00	1,00
Sweden	1,00	1,00	1,00
Wales	1,00	1,00	1,00
Austria	1,89	1,93	0,98
Norway	2,99	3,11	0,96
Netherlands	1,98	2,08	0,95
Germany	3,28	3,52	0,93
France	1,43	1,54	0,92
Scotland	1,00	1,08	0,92
Finland	1,59	1,77	0,90
Czech Rep.	2,09	2,34	0,90
Italy	1,05	1,17	0,89
Switzerland	1,25	1,50	0,84
Belgium	1,00	1,24	0,81
Ireland*	1,44	1,80	0,80
		Avg. Eff.	**0,90**

**Includes Northern Ireland*

TABLE 5
Scale efficiency: Ratio-variables model.

Country	Ratio-variables models		
	BCC-Eff. (M_3)	CCR-Eff. (M_4)	Scale Eff.
Portugal	1,00	1,00	1,00
Scotland	1,00	1,00	1,00
Spain	1,00	1,00	1,00
Sweden	1,00	1,00	1,00
Wales	1,00	1,00	1,00
Ireland*	1,42	1,46	0,97
France	1,94	2,01	0,97
Denmark	1,09	1,14	0,96
Netherlands	6,13	6,59	0,93
Austria	1,84	2,01	0,92
Germany	6,22	7,07	0,88
England	1,10	1,26	0,87
Switzerland	2,46	2,88	0,86
Finland	1,00	1,30	0,77
Belgium	2,05	2,91	0,70
Norway	1,00	1,82	0,55
Italy	1,00	2,01	0,50
Czech Rep.	1,00	2,79	0,36
		Avg. Eff.	**0,79**

**Includes Northern Ireland*

The results given after solving the models with only one output, models M_5 and M_6, that we do not report just for reasons of space, show that although the set of efficient nations can vary slightly, the efficiency scores obtained by the different nations are very similar in the models with one or two outputs. This seems to indicate that the second output, GPRTD, does not provide much additional information. To confirm this fact, we have calculated the correlation between GPET and GPRTD and, as expected it is close to 1 (0.96). However, we consider that the initial models, with two outputs, are more appropriate because they comprise all the information based on our dataset.

Taking into account all the information derived from the previous analysis, we could deduce that both models M_1 and M_2, and the results derived from them, are the most appropriate models to analyze the efficiency of the nations presented.

We can derive some additional information from the results given by the models. In radial output-oriented models, the output projections are obtained directly using the corresponding efficiency score. If we look, for example, at the results given by Model M_1, reported in Table 2, we can observe that Austria, with a score of 1.89, should increase the level of their outputs by 89%, maintaining the three input values in order to become efficient. Therefore, the new radially projected output values should be $GPET^a$=163 and $GPRTD^a$=10. In Table 6 we have calculated, for each inefficient nation given by Model M_1, the efficiency score, the necessary percentage of improvement in the level of the outputs in order to be classified as efficient (%IMP), the initial values of their outputs (GPET and GPRTD) and the targets for these outputs to reach efficiency ($GPET^a$ and $GPRTD^a$). The resulting numbers of $GPET^a$ and $GPRTD^a$ have been rounded up to the next higher integer value.

TABLE 6
Benchmarking analysis: Current outputs and efficient targets.

Nation	Eff.	%IMP	GPET	$GPET^a$	GPRTD	$GPRTD^a$
Austria	1.89	89%	86	163	5	10
Czech Republic	2.09	109%	51	107	0	0
Finland	1.59	59%	89	142	4	7
France	1.43	43%	474	678	21	30
Germany	3.28	228%	261	857	6	20
Ireland*	1.44	44%	250	360	9	13
Italy	1.05	5%	258	271	10	10.5
Netherlands	1.98	98%	122	242	6	12
Norway	2.99	199%	64	192	1	3
Switzerland	1.25	25%	81	102	3	4

**Includes Northern Ireland*

[a] Target of the outputs to be efficient.

If we look at the results presented in Table 6, we can observe that Germany should increase the values of GPET and GPRTD by 228%, which means that the number of people playing the European tour should increase from 261 to 857 and the players participating in the Race to Dubai from 6 to 20, to be classified as an efficient nation. Italy, by contrast, should qualify only one more player for the Race to Dubai and increase the number of players in the European Tour from 258 to 271 to reach efficiency. The information given in Table 6 is very valuable and gives nations an idea of what they need to do in order to become efficient.

However, sometimes, the levels required to achieve efficiency, are too demanding and it could be more reasonable to propose smaller and more feasible changes as a first step to reach efficiency. In these cases, we could apply the methodology proposed by Barr, Durchholz, and Seiford (1994) in which the authors layer and rank-order the DMUs, separating them into different groups of 'comparable' efficiency. The tiered DEA procedure proposed by the authors begins with the traditional data envelopment analysis establishing the set of efficient DMUs, which form the first tier. Then, these DMUs are eliminated from the data set and the procedure is applied recursively until all DMUs are assigned to a particular tier. Each tier envelops all the subsequent tiers.

Applying this methodology to our initial BCC-OO model, M_1, we have found three different tiers:

Tier 1: Belgium, Denmark, England, Portugal, Scotland, Spain, Sweden and Wales

Tier 2: Austria, Czech Republic, Finland, France, Ireland, Italy and Switzerland

Tier 3: Germany, Netherlands and Norway

As we can observe, we have obtained three different subgroups or layers, where the nations in each one are 'comparable' in terms of efficiency. This also allows us to calculate more achievable targets for the very inefficient nations in order to get a reasonable reduction in their inefficiency. For example, if we apply the benchmarking analysis once we have eliminated from the dataset the efficient nations in tier 1, the new efficient targets of nations in tier 3 are calculated taking as reference the set of nations in tier 2, and these targets should be much more achievable than those previously obtained, shown in Table 6. Results are presented in Table 7. The second column indicates the new efficiency score (when compared with the nations in Tier 2) and the third the new corresponding percentage of improvement in their outputs; columns 4 and 7 show the initial values of the outputs; the fifth and the eighth columns represent the necessary targets (presented in Table 3) in order to achieve efficiency; GPET[b] and GPRTD[b] indicate the new targets in order to get closer to efficiency, i.e. to change from Tier 3 to Tier 2.

TABLE 7
Benchmarking analysis with tiered DEA.

Nation	New Eff.	New %IMP	GPET	GPET[a]	GPET[b]	GPRTD	GPRTD[a]	GPRTD[b]
Germany	1.82	82%	261	857	476	6	20	11
Netherlands	1.13	13%	122	242	138	6	12	7
Norway	1.74	74%	64	192	112	1	3	2

[a] Target of the outputs to be efficient. b Target of the outputs to get closer to efficiency.

For example, the Netherlands would need an increase of 98% in their outputs to become efficient, as we have reported in Table 6. However, if they achieved an increase of 13% in their outputs, i.e. the number of professional golfers playing the European Tour rose from 122 to 138 (instead of 242) and they got only one more golfer to take part in the Race to Dubai (7 instead of 6), the Netherlands would pass over to Tier 2, improving their level of efficiency, having now an efficiency comparable to the nations in that tier and finding themselves much closer to efficient nations in Tier 1. Germany and Norway should need improvements of around 80% to change to Tier 2, in contrast to the improvements of around 200% necessary to be classified as efficient in the initial analysis. These output-improvements are much more acceptable and would represent a first step towards achieving efficiency.

This research could be employed as a basis to investigate which of the policies carried out by the different nation federations have influenced their efficiency in the emergence of elite golfers. This could help the nations rated as inefficient to decide if these policies could be implemented in order to become efficient.

Moreover, the analysis carried out in this work, applied to European nations, could be extended to America and Asia, studying if there are significant differences in the strategies carried out in the nations of the different continents. The methodology carried out in this paper could also be extended to different sports, such as tennis, formula 1 or moto GP, to mention just a few.

As a limitation or possible improvement of the analysis, maybe alternative inputs and outputs should be used, like climate, the quality of players, players economic profits...Moreover, GPET and GPRTD are highly correlated outputs, so new outputs related to elite golf players maybe can be used to improve the analysis.

CONCLUSIONS

In this paper, we have analyzed a sample of eighteen European nations in order to classify them as efficient or inefficient, according to their ability to generate elite professional golfers. We have used information relative to a set of 7 variables, considering 3 inputs and 2 outputs, with a database from 2014. To carry out this study, we have employed Data Envelopment Analysis and have developed several BCC-OO and CCR-OO models in order to evaluate the efficiency of the nations. We have analyzed the different models and the robustness of the results they provide in order to propose the most appropriate model for this analysis. In this case, the BCC-OO and CCR-OO models with raw data seem the most adequate.

As by-products, we have measured how far each inefficient nation has to go in order to reach efficiency. Some inefficient nations are very close to being efficient while some others, by contrast, are really far. We have also identified, for each one, the role models that can be used for the design of new golf strategies in order to improve performance. Some nations, as for example Spain is very relevant in this sense, because it has played acted as a benchmark on most occasions. This analysis can indicate general strategies of improvement for inefficient regions. Moreover, in these cases, we have also calculated the efficient targets for the outputs, i.e. the levels to achieve in order to become efficient. This analysis can be used by inefficient countries to analyze the golf strategies and policies of efficient countries to produce more elite players. Sometimes, the necessary improvement of the outputs to be classified as efficient is too demanding and really difficult to reach. In those cases, we have proposed a stepwise strategy that allows inefficient nations to find a more achievable path towards efficiency by first reaching several intermediate points.

ACKNOWLEDGEMENTS

The authors appreciate the financial support from the Spanish Ministry for Economy and Competitiveness (Ministerio de Economía, Industria y Competitividad), the State Research Agency (Agencia Estatal de Investigación) and the European Regional Development Fund (Fondo Europeo de Desarrollo Regional) under grant MTM2016-79765-P (AEI/FEDER, UE).

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