PERFORMANCE EVALUATION OF GOALKEEPERS OF SLOVAK FOOTBALL LEAGUE

Natalie Pelloneová[1]; **Michal Tomíček**[2]
Technical University of Liberec, Faculty of Economics,
Department of Business Administration and Management,
Studentská 1402/2, 461 17 Liberec 1, Czech Republic
e-mail: [1]natalie.pelloneova@tul.cz; [2]michal.tomicek@tul.cz

Abstract

Football is a popular sport in Slovakia. Every year football clubs spend large sums of money on buying individual players. However, there is a small number of scientific studies dealing with statistical, economic dimensions, and performance evaluation of football players. The performance of individual players, as well as the performance of the whole team, are very important indicators that predetermine the success of the whole club. The aim of this research is to develop a new system for evaluating the efficiency of football players and then apply this system to football practice and identify technically efficient players. The present research uses the data envelopment analysis, specifically the input-oriented Charness, Cooper, Rhodes model and the Andersen-Petersen super-efficiency model. Both models are empirically applied to only one group of football players, namely goalkeepers of the first and second Slovak football leagues in the 2020/21 season. The model proposed in this article attempts to incorporate greater objectivity into making decisions and thus may be an important step in developing a systematic methodology for evaluating not only goalkeepers but also other player positions.

Keywords

Football; Sport; Goalkeeper; Data envelopment analysis; Efficiency; Super-efficiency.

Introduction

The world of sport is constantly changing and evolving. The sports industry has been evolving in recent years, especially economically. The sums of money that are transferred between players in the sports industry today are incomparably higher than those of the last decade. One of the fastest developments has occurred in the world's most widespread sport, football. The transfer sums of the best players in the world exceed hundreds of millions of euros, in terms of Czech crowns it is in the order of billions.

In foreign developed Western countries, such as Spain, billionaire clubs backed by influential corporations or global oligarchs from the energy and petrochemical industries occupy Germany, France, and England, the top positions in the league tables. While the last places are occupied by formerly successful clubs with a rich history and tradition, which are now teetering between staying in the top competitions and relegation. The middle of the tables is usually very balanced both in terms of sporting performance and in terms of financial background of the clubs.

Football has a relatively long history in Slovakia and its popularity is quite high. In Slovakia, research by Machlica and Šiškovič [1] has recorded a relatively high number of football clubs and footballers relative to the population. Slovakia performs relatively above average in football compared to other countries, e.g., the national team was ranked 17th-29th in the

UEFA international rankings in 2020 according to Melek and Dedík [2]. In Slovakia, the wealth diversification of the individual clubs of one competition is not yet at such a level. However, a similar pattern applies to the Slovak top football competition. The clubs fighting for the top spot are backed by influential businesspersons or foreign corporations. The Slovak top competition is currently (2022) economically dominated by a club from the capital city together with, in recent years dominant, Dunajská Streda [3]. It can be concluded that the entry of entrepreneurs into the running of football clubs is a prerequisite for their further development and an increase in the probability of achieving potential success.

Some football clubs, such as Slovan Bratislava, Dunajská Streda or Spartak Trnava, are making significant profits, while others are experiencing negative financial results, such as Sereď and Senica. In this case, it is desirable to ask how the club in question manages its resources to achieve its results. The focus should be on whether the club is using its resources appropriately to achieve the best possible results. It is conceivable that a club whose players are relatively cheap can get "interesting" results [4].

1 Research Objectives

The aim of this article is to develop a model that can be used by clubs, managers and coaches to evaluate the efficiency of football players. Empirically, the model is applied to only one group of football players, namely goalkeepers of the first and second Slovak football leagues in the 2020/2021 season. The aim of the article is to analyze the efficiency of Slovak goalkeepers in the first and second league, which have very different resources [4]. The results of the research may be interesting not only for fans, but also for managers of football clubs and goalkeepers themselves. The resulting evaluation may reveal how players perform and may have an impact on their market value. Goalkeepers themselves will want to know which benchmark players to use for comparison when improving their own game. The model created could be used to not only improve the efficiency of goalkeepers' play and create individual training programs but for players in other positions.

2 Literature Review

In the following part of the article, selected authors who apply various statistical and mathematical methods to evaluate the performance of goalkeepers in different sports disciplines are briefly summarized. A large number of studies deal with the evaluation of handball goalkeepers, e.g., Medina et al. [5], Gómez-López et al. [6], Cvenić [7] and Pascual Fuertes et al. [8]. The study by Fuertes et al. [8] aims to analyze the effect of goalkeeper performance on handball team performance based on data from the last six seasons of the Asobal League. The research is based on linear regression analysis, mean comparison test and logit multinomial test. The results of their research indicated that goalkeepers' efficiency is a relevant variable to explain the performance of the whole team. Through their research, they concluded that higher goalkeeper efficiency translates into better team classification. They further add that top teams have better goalkeeper efficiency than other teams. In the sport discipline of futsal, Szwarc et al. [9], Oszmaniec and Szwarc [10] evaluate goalkeepers in their research.

Research on the efficiency of entire teams in football using data envelopment analysis has been carried out in various studies, e.g., Halkos and Tzeremes [11], Espitia-Escue and García-Cebrián [12], but usually neglected to analyze the efficiency of goalkeepers. Few studies have been conducted on goalkeepers in football e.g., Kapera [13] and Alp [14]. Alp [14] evaluates 32 goalkeepers from the 2002 FIFA World Cup using an output-oriented CCR model and the Andersen-Petersen super-efficiency model. Alp uses as output variables: the ratio / number of goals against per match, number of penalty kicks saved, number of other saves, free kicks

saved ratio per match, corner kicks saved ratio per match, fast breaks saved ratio per match, individual saves ratio per match.

Based on the above, it can be concluded that there are only a limited number of studies dealing with football players, especially goalkeepers. Thus, this article aims to add another method to the literature that can be used to evaluate football goalkeepers based on easily observable game statistics.

3 Methodology and Data

The aim of the research is to use data envelopment analysis to calculate the level of technical efficiency and then to evaluate and compare the efficiency of goalkeepers playing in the 1st and 2nd football league in Slovakia. Goalkeepers' efficiency in both competitions was analyzed in the 2020/2021 season. Goalkeepers' efficiency was evaluated only based on data from the regular game part of the two investigated football competitions.

3.1 Data Set

The first part of the article focused on the evaluation of the efficiency of goalkeepers playing in the top Slovak football league called Fortuna Liga. A total of 12 football clubs participated in the Slovak top football competition in the 2020/2021 season. The second part of the article was devoted to the evaluation of goalkeepers' efficiency playing in the 2nd Slovak league. A total of 15 clubs participated in the 2nd football league in the 2020/2021 season.

Only goalkeepers who played at least one game in the 2020/2021 season were included in the analysis. The database consists of 32 goalkeepers who played in the Fortuna Liga and 47 goalkeepers who played in the 2nd Slovak football league in the 2020/2021 season.

The data used for the research come from the official database of the Fortuna League [15] and is supplemented by databases of companies from the football environment. In particular, data from Livesport [16] and Transfermark [17] were used.

3.2 Data Envelopment Analysis

To calculate the technical efficiency of goalkeepers in the 1st and 2nd Slovak football league in the 2020/2021 season, the input-oriented CCR-I and then AP model was used. The DEA methodology is a non-parametric technique that helps to estimate the technical efficiency of a set of decision-making units (further DMUs). The efficiency score in the DEA method is bounded by an interval from 0 to 1, with a score of 1 being achieved by the efficient unit (in this case the goalkeeper). Input-oriented models help determine how much the inputs need to be reduced to make the evaluated unit efficient. The CCR model operates under the assumption of constant returns to scale, allowing the calculation of an overall technical efficiency score (further OTE) regardless of returns to scale [18]. The input-oriented CCR model evaluates the efficiency by solving the following linear programming problem.

Minimize
$$\theta_q \tag{1}$$

S.t.
$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta_q x_{iq}, \qquad i = 1,2,\dots,m,$$
$$\sum_{j=1}^{n} y_{kj}\lambda_j - s_k^+ = y_{kq}, \qquad k = 1,2,\dots,r, \tag{2}$$
$$\lambda_j \geq 0, \quad j = 1,2,\dots,n,$$

where

λ_j, j = 1, 2, ..., n are weights of all DMU*s*,
s_i^-, i = 1, 2, ..., m and s_k^+, k = 1, 2, ..., r are slack/surplus variables, and
θ_q is the efficiency score of the DMUq.

In the second step of the research, the model by Andersen and Petersen (1993) was applied to the data. This model allows the efficient unit to achieve efficiencies greater than 1 for input-oriented models. The main advantage of this model is the possibility to further classify the efficient units. Jablonský and Dlouhý [19] formulate an input-oriented AP model assuming CRS using relations (3) and (4). If the unit under consideration is classified as efficient, then $\theta_q^{AP} > 1$.

Minimize
$$\theta_q^{AP} \tag{3}$$

S.t.
$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta_q^{AP} x_{iq}, \quad i = 1, \dots, m,$$
$$\sum_{j=1}^{n} y_{kj}\lambda_j - s_k^+ = y_{kq}, \quad k = 1, \dots, r, \tag{4}$$
$$\lambda_j \geq 0, \quad j = 1, \dots, n, j \neq q,$$
$$\lambda_q = 0.$$

Eight variables were included in the DEA model due to the number of goalkeepers evaluated. The only input variable is the market value of each goalkeeper (further MV). On the other hand, the research will consider several outputs. The first output is the number of minutes played (further MIN). The importance in the team increases every time a goalkeeper is selected to play. This variable takes into account whether the goalkeeper played the whole game or came on as a substitute. Other output variables are close range shots saved (further CSS), mid-range shots saved (further MSS), long range shots saved (further LSS), stopped shots (further SS), supersaves (further S), and accurate passes (further AP). Table 1 summarizes the statistics on these variables.

Tab. 1: *Descriptive statistics of input and output variables*

Variable	**League**	**1st league**	**2nd league**
	Number of goalkeepers	**32**	**47**
Market value (thousand EUR)	Mean	228.91	94.15
	Standard deviation	197.88	80.46
	Max	1000	400
	Min	50	25
Minutes played	Mean	1143.44	826.77
	Standard deviation	1055.44	799.95
	Max	3144	2628
	Min	91	91
Close range shots saved	Mean	10.50	7.00
	Standard deviation	11.31	7.20
	Max	41	24
	Min	0	0
Mid range shots saved	Mean	17.81	13.64
	Standard deviation	19.15	11.77
	Max	62	47
	Min	0	0
Long range shots saved	Mean	15.16	11.72
	Standard deviation	16.68	11.57
	Max	57	48
	Min	0	0
Stopped shots	Mean	20.53	15.72
	Standard deviation	21.48	15.13
	Max	72	73
	Min	0	0
Supersaves	Mean	12.94	10.04
	Standard deviation	14.71	9.22
	Max	59	38
	Min	0	0
Accurate passes	Mean	335.22	256.89
	Standard deviation	339.04	246.56
	Max	1216	815
	Min	17	13

Source: Own

4 Results of the Research

The CCR-I model was applied to the data; the results are shown in Table 2. Table 2 shows that about 15% of the goalkeepers in the first football league are efficient. The obtained OTE score averages around 0.5. On the other hand, in the second football league, only 4% of the goalkeepers were efficient. The obtained OTE scores reach lower average values (about 0.38).

Tab. 2: *Efficiency results for both football leagues*

League	**Number of efficient units**	**Proportion**	**Average OTE score**
1st league	5	15.63%	0.4945
2nd league	2	4.26%	0.3795

Source: Own

The detailed results of the research are summarized in Table 3. The CCR-I model was applied to a set of 32 goalkeepers in the first league. The goalkeepers identified as efficient in the analysis are listed in Table 3. These are the five goalkeepers. It is typical for all goalkeepers that they achieved above average values in saves. On the other hand, their market value is below average. For example, Adrian Chovan was the best goalkeeper in terms of the variables mid-range shots saved and supersaves. He also achieved the highest market value of the efficient goalkeepers of the first league (EUR 300 thousand). The highest market value of the whole set of 32 goalkeepers of the first league was attributed to Dominik Greif (EUR 1 million). Dominik Greif, however, achieved a very low OTE score (0.197) and can be classified as an inefficient unit according to the CCR-I model.

Tab. 3: *Efficient goalkeepers in the 1st Slovak football league*

Name	MV (thousand EUR)	MIN	CSS	MSS	LSS	SS	S	AP
Tomas Jenco	100	1467	8	15	8	15	10	440
Tomas Frystak	150	2150	28	37	22	32	26	542
Igor Semrinec	150	1586	18	26	24	32	12	544
Matej Markovic	150	2332	16	23	28	29	21	558
Adrian Chovan	300	3141	31	62	56	62	59	1078
Mean	*170*	*2135.20*	*20.20*	*32.60*	*27.60*	*34.00*	*25.60*	*632.40*
Max	*300*	*3141*	*31*	*62*	*56*	*62*	*59*	*1078*
Min	*100*	*1467*	*8*	*15*	*8*	*15*	*10*	*440*

Source: Own

Table 4 below shows the efficient goalkeepers in the second league. From the set of 47 goalkeepers, only two goalkeepers were marked as efficient in terms of OTE score – Matej Luksch and Milan Vincler. These goalkeepers were above average in terms of the output variables in all saves. Goalkeeper Matej Luksch recorded maximum mid and long-range shots saved, stopped shots, and accurate passes in the 2020/21 season. These great stats ultimately resulted in an efficient score. This was a goalkeeper with a relatively low market value (75 thousand euros). The highest market value out of the entire set of 47 goalkeepers in the second league was attributed to Samuel Petras (EUR 400 thousand). Samuel Petras, however, achieved a very low OTE score (0.017) and can be classified as an inefficient unit according to the CCR-I model.

Tab. 4: *Efficient goalkeepers in the 2nd Slovak football league*

Name	MV (thousand EUR)	MIN	CSS	MSS	LSS	SS	S	AP
Matej Luksch	75	2500	18	47	48	73	22	815
Milan Vincler	50	1900	17	41	28	27	23	527
Mean	*62.5*	*2200*	*17.5*	*44*	*38*	*50*	*22.5*	*671*
Max	*75*	*2500*	*18*	*47*	*48*	*73*	*23*	*815*
Min	*50*	*1900*	*17*	*41*	*28*	*27*	*22*	*527*

Source: Own

On average, goalkeepers in the second league had to play more minutes to be efficient than goalkeepers in the first league. Efficient goalkeepers in the second league also had more saves on average, excluding supersaves, and also more accurate passes. The market value of efficient goalkeepers in the second league was also at a lower financial level than that of first league goalkeepers. In the second part of the research, the efficient goalkeepers were further classified using the AP model of super-efficiency. The results of this evaluation are summarized in Table 5.

Tab. 5: *Ranking of efficient goalkeepers*

Name	Nationality	Age	Height	League	Team	AP model	Ranking
Tomas Frystak	CZ	34	193	1st	Senica	1.6087	1.
Adrian Chovan	SK	26	192	1st	Zlate Moravce	1.1917	2.
Tomas Jenco	SK	33	182	1st	Pohronie	1.1828	3.
Matej Markovic	HR	25	192	1st	Michalovce	1.1781	4.
Igor Semrinec	SK	34	188	1st	Trencin	1.0093	5.
Matej Luksch	CZ	23	191	2nd	Liptovsky Mikulas	1.4427	1.
Milan Vincler	SK	28	189	2nd	Trebisov	1.4403	2.

Source: Own

The evaluation shows that the best-rated goalkeeper in the first Slovak football league is Tomas Frystak from the Czech Republic. In the second Slovak football league, the best-rated goalkeeper is also the Czech goalkeeper Matej Luksch.

Conclusion

The main aim of the thesis was to propose an approach to the analysis and evaluation of the best goalkeepers in two Slovak football competitions. The CCR-I model was used to evaluate the goalkeepers. Subsequently, the AP super-efficiency model was used to determine the ranking of the best goalkeepers.

In neither case were the most valuable goalkeepers assigned to a set of efficient units. This fact can be interpreted to mean that the most valuable goalkeepers in both competitions should have higher performance as measured by the above game statistics according to the CCR-I model. The research also showed that the market value of the efficient goalkeepers of the first league was at a higher financial level than the value of the goalkeepers of the second league.

Given the current economic and financial situation of football clubs, there is an increased need to know how efficiently a club is using its resources. Efficiency analysis is used to calculate the performance scores of players and to determine the deficiency aspects and the number of inefficient players. The advantage of the DEA methodology is to establish benchmarks for inefficient players and identify sources of inefficiency. Along with general insights and experiences, sports managers can consider DEA efficiency analysis when developing teams. This evaluation model should significantly contribute to the tactical preparation of goalkeepers for the match, distinguish the quality of individual goalkeepers more accurately, and evaluate the overall efficiency at the end of the match. Another possible extension of this method is its application to other player positions.

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HODNOCENÍ VÝKONNOSTI BRANKÁŘŮ SLOVENSKÉHO FOTBALU

Fotbal je na Slovensku oblíbené sportovní odvětví. Fotbalové kluby vynakládají každoročně nemalé peněžní částky na nákup jednotlivých hráčů. Přesto existuje malé množství vědeckých studií, které by se zabývaly statistickými, ekonomickými rozměry a hodnocením výkonnosti fotbalových hráčů. Výkony jednotlivých hráčů stejně jako výkon celého týmu jsou velmi důležité ukazatele, které předurčují úspěch celého klubu. Cílem tohoto výzkumu je vytvořit nový systém hodnocení efektivity fotbalových hráčů a následně tento systém aplikovat do fotbalové praxe a identifikovat technicky efektivní hráče. V předkládaném výzkumu je využito analýzy obalových dat, konkrétně vstupově orientovaného Charness, Cooper, Rhodes modelu a modelu super-efektivnosti Andersen-Petersen. Oba modely jsou empiricky aplikovány na pouze jednu skupinu fotbalových hráčů, konkrétně brankáře první a druhé slovenské fotbalové ligy v sezóně 2020/21. Model navržený v tomto článku se snaží do rozhodování začlenit větší objektivitu, a může tak být důležitým krokem při vývoji systematické metodiky hodnocení nejen brankářů, ale i hráčů na ostatních herních pozicích.

LEISTUNGSBEWERTUNG VON TORHÜTERN IM SLOWAKISCHEN FUßBALL

Fußball ist ein beliebter Sport in der Slowakei. Jedes Jahr geben die Fußballvereine große Summen für den Kauf einzelner Spieler aus. Es gibt jedoch nur wenige wissenschaftliche Studien, die sich mit den statistischen und ökonomischen Dimensionen sowie der Leistungsbewertung von Fußballspielern befassen. Die Leistung einzelner Spieler und die Leistung der gesamten Mannschaft sind sehr wichtige Indikatoren, die den Erfolg des gesamten Vereins vorhersehen lassen. Ziel dieser Forschung ist es, ein neues System zur Bewertung der Effektivität von Fußballspielern zu entwickeln und dieses System dann in der Fußballpraxis anzuwenden und technisch effektive Spieler zu identifizieren. Die vorliegende Untersuchung verwendet die Analyse von Umschlagdaten, insbesondere das input-orientierte Modell von Charness, Cooper, Rhodes und das Super-Effektivitäts-Modell von Andersen-Petersen. Beide Modelle werden empirisch auf eine einzige Gruppe von Fußballspielern angewandt, nämlich die Torhüter der ersten und zweiten slowakischen Fußballliga in der Saison 2020/21. Das in diesem Beitrag vorgeschlagene Modell versucht, eine größere Objektivität in die Entscheidungsfindung einzubringen, und kann daher ein wichtiger Schritt bei der Entwicklung einer systematischen Methodik zur Bewertung nicht nur von Torhütern, sondern auch von Spielern auf anderen Positionen sein.

OCENA SKUTECZNOŚCI BRAMKARZY SŁOWACKIEJ PIŁKI NOŻNEJ

Piłka nożna jest na Słowacji popularną dyscypliną sportową. Co roku kluby piłkarskie wydają duże sumy pieniędzy na zakup poszczególnych zawodników. Mimo to istnieje niewielka liczba opracowań naukowych, które dotyczą statystycznego, ekonomicznego wymiaru i oceny skuteczności piłkarzy. Wyniki poszczególnych zawodników, jak i wyniki całego zespołu są bardzo ważnymi wskaźnikami, które przesądzają o sukcesie całego klubu. Celem przeprowadzonych badań jest stworzenie nowego systemu oceny efektywności zawodników piłki nożnej, a następnie zastosowanie tego systemu w praktyce piłkarskiej i identyfikacja zawodników skutecznych technicznie. W ramach opisywanych badaniach wykorzystano analizę obwiedni danych, a konkretnie model Charnesa, Coopera, Rhodesa zorientowany na nakłady oraz model nadefektywności Andersena-Petersena. Oba modele zastosowano empirycznie tylko do jednej grupy piłkarzy, a mianowicie bramkarzy pierwszej i drugiej słowackiej ligi piłki nożnej w sezonie 2020/21. Zaproponowany w niniejszej pracy model próbuje wprowadzić do procesu decyzyjnego większą obiektywność, a tym samym może być ważnym krokiem w rozwoju systematycznej metodyki oceny nie tylko bramkarzy, ale także innych pozycji zawodników.