

## LATENT STRUCTURE OF EFFICIENCY AT 2009 CONTINENTAL (ZONE) BASKETBALL CHAMPIONSHIPS

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(Original scientific paper)

Slobodan Simović<sup>1</sup> and Đorđe Nićin<sup>2</sup>

<sup>1</sup>University of Banja Luka, Faculty of Physical Education and Sport, Banja Luka,  
Bosnia and Herzegovina

<sup>2</sup>Alfa University, Belgrade, Faculty of Sport Management, Belgrade, Serbia

### Abstract:

*Applying the method of main components by Hotelling and the method of rotation of the main components, i.e. Varimax rotations by Keiser, the latent structure of basketball efficiency was established. Six factors have been isolated by means of which the accounted variance has been 77,16%. Factorization was performed on the entire sample of all game-winning teams, that is 220. Latent dimensions, i.e. factors have been extracted on the basis of 13 manifest parameters of efficiency. Faktorska analiza sa ekstrahovanih šest latentnih dimenzija, i izdvajanjem tri komponente koje objašnjavaju mnogo veći dio varijanse od preostalih komponenti, ukazuje na to da se latentna struktura košarkaške efikasnosti na Zonskim seniorskim prvenstvima 2009. godine može objasniti: faktorom šuta za tri poena, faktorom izvođenja slobodnih bacanja i faktorom opšte napadačke efikasnosti.*

**Key words:** FIBA, situational variables, factor analysis

### INTRODUCTION

We have witnessed a phenomenon that even at the lowest levels of basketball competitions certain data are collected that can be referred to as "basketball statistics". These data are then subject to various forms of analysis, from simple ones, arithmetic quantification to modern multivariate statistical methods by means of which sport scientists try to get to the essence of the latent structure of the phenomenon itself.

Applying the alpha factor model with Guttman-Kaiser criterion and oblimin transformation, the following authors dealt with the latent structure of basketball efficiency: Trinić, N. Viskić-Štalec, Štalec, Dizdar and Birikić (1995). Precisely 64 games of the World Championship in Toronto 1994 were observed. Sporiš, Šango, Vučetić and Tonči (2006) observed 134 games of the regional Goodyear league in the season of 2004/2005. Thirteen (13) standard indicators of situational effi-

ciency were also observed by the means of the same statistical methodology. Šeparović and Nuhanović (2008) identified the latent structures of basketball efficiency by utilization of the factor analysis based on fifteen (15) standard indicators. The sample pertained to thirty (30) games of BiH National Championship in the League of top 6 teams.. Simović, Matković and Mijanović (2010) identified, applying the method of main components by Hotelling and the method of rotation of the main components, i.e. Varimax rotations by Keiser, identified the latent structure of basketball based on the fourteen (14) manifest efficiency indicators. It is recognized as a group sample constituted of game-winning teams at the WC in Greece (62 teams), WC in USA (62 teams) and WC in Japan (80 teams).

The standard indicators of efficiency do not occur isolated so it is therefore assumable that there is a latent structure which accounts for their corre-

Table 1. Correlation Matrix

	a2	m2	a3	m3	aft	mft	or	dr	as	tuo	st	bs	pf
a2	1,000												
m2	,738	1,000											
a3	-,406	-,334	1,000										
m3	-,337	-,320	,748	1,000									
aft	-,136	-,064	-,166	-,132	1,000								
mft	-,202	-,110	-,131	-,090	,910	1,000							
or	,478	,243	,111	-,038	,005	-,044	1,000						
dr	,213	,265	-,003	-,004	,048	,022	,091	1,000					
as	,097	,185	,248	,465	-,106	-,076	-,033	,075	1,000				
to	-,011	,024	-,246	-,220	,071	,092	,092	,216	-,111	1,000			
st	,208	,271	,095	,082	,081	,067	,107	-,038	,182	,171	1,000		
bs	,111	,085	-,060	-,051	-,088	-,080	,040	,153	,240	,096	,092	1,000	
pf	-,146	-,150	-,029	-,110	,141	,147	-,084	-,219	-,064	,033	-,112	-,031	1,000

lation and influence onto the final result of a game.

The aim of this research is to establish the latent structure of the observed manifest parameters of basketball efficiency at Zone (Continental) Championships in the year of 2009.

## METHODS

### Sample of entities

The research includes sixty-two (62) games at 2009 FIBA Africa Championship for Men, held from August 5-15, 2009 in Tripoli and (Libya), sixty-two (62) at 2009 FIBA Asia Championship for Men, held from August 6 to 16, 009 in Tianjin City (China), forty (40) games at 2009 FIBA Americas Championship for Men, held from August 26 to September 6, 2009 in San Juan (Puerto Rico), fifty-four (54) games at EuroBasket 2009, held from September 7 to 20, 2009 Gdansk, Poznan, Warsaw, Wroclaw, Bydgoszcz, Lodz and Katowice (Poland), and two (2) 2 games at 2009 FIBA Oceania Championship for Men, held from August 23 to 25, 2009 in Melbourne (Australia) and Wellington (New Zealand).

The statistical processing encompassed the results of basketball efficiency of game-winning teams. As there were two hundred and twenty (220) games, the total number of game winners corresponded to that number, i.e. the group entities.

### Sample of variables

The manifest variables were standardly observed parameters of basketball efficiency: *two-points made total* (M2), *two-points attempted total* (A2), *three-points made total* (M3), *three-ponits attempted total* (A3), *free throws made* (MFT), *free throws attempted* (AFT), *offensive rebounds* (OR), *defensive rebounds* (DR), *assists* (AS), *personal fouls* (PF), *turnovers* (TO), *steals* (ST) and *blocks* (BS).

### Research procedures

In order to form a data base, we used the standard indicators of basketball efficiency as defined by FIBA, and which were registered in the year of 2009 at Continental Championships for Men. The data were obtained from the official sites of the respective championships: [www.libya2009.fiba.com](http://www.libya2009.fiba.com), [www.china2009.fiba.com](http://www.china2009.fiba.com), [www.puertorico2009.fiba.com](http://www.puertorico2009.fiba.com), [www.eurobasket2009.org](http://www.eurobasket2009.org) and official FIBA web site, i.e. *archive historical data from FIBA and FIBA zones events since 1930* – [archive.fiba.com](http://archive.fiba.com). The evaluation of standard indicators of efficiency was put in place under the same conditions. The data gathering process is regulated by World Regulations – Official Statistics Sheet and Basketball Statistics Manual. The process is carried away by two data keepers using the computer software designed for

Table 2. Kaiser-Mayer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,495
Bartlett's Test of Sphericity	Approx. Chi-Square	1201,097
	df	78
	Sig.	,000

Table 3. Factor Analysis – Communalities

	Initial	Extraction
a2	1,000	,881
m2	1,000	,794
a3	1,000	,844
m3	1,000	,857
aft	1,000	,949
mft	1,000	,946
or	1,000	,677
dr	1,000	,768
as	1,000	,761
to	1,000	,839
st	1,000	,644
bs	1,000	,586
pf	1,000	,486

this specific purpose. One data keeper is in charge of data input. The other, known as *prompter*, is specially trained to identify, in a proper manner, the standard indicators of situational efficiency in basketball, and to present data to the operator. In case of incorrect data gathering, there are sanctions imposed on the accountable person and the game organizer.

### Statistical analysis

The parameters of basketball efficiency observed in a standard manner were subject to the basic statistical procedure resulting in a correlation matrix.

The latent structure of parameters of basketball efficiency observed in a standard manner was established by the means of factor analysis. In the procedure of factorization we used the method of main components by Hotteling, and the method of orthogonal rotation of main components – Varimax procedure.

The criterion for the number of factors relevant to the procedure was based on the value of characteristic lambda roots ( $\lambda_1$ ).

### RESULTS

Table 1 shows the correlation matrix of manifest variables. Out of 78 variables, 23 have shown a high level of significance (.01) or 29.49%. That indicates a weak correlation correlation among monitored variables. The highest correlation was

Table 4. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,690	20,692	20,692	2,690	20,692	20,692	2,277	17,515	17,515
2	2,333	17,944	38,636	2,333	17,944	38,636	1,980	15,234	32,748
3	1,681	12,929	51,566	1,681	12,929	51,566	1,910	14,689	47,438
4	1,195	9,195	60,760	1,195	9,195	60,760	1,376	10,588	58,026
5	1,104	8,495	69,255	1,104	8,495	69,255	1,310	10,074	68,099
6	1,028	7,906	77,161	1,028	7,906	77,161	1,178	9,062	77,161
7	,932	7,171	84,332						
8	,769	5,912	90,244						
9									
10									
11									
12	,120	,919	99,345						
13	,085	,655	100,000						

established with the variables of “free throws made” and “free throws attempted” (.910). The highest number of correlation coefficients (7) was obtained in comparison between “2-points attempted total” and the other variables and it accounted for the largest proportion of co-variability when dealing with the indicators of basketball efficiency.

The value of Kaiser-Mayer-Olkin measure of sampling adequacy indicates the value of .495. It is preferable to have this value as high as possible (maximum 1), but bearing in mind that the analyzed correlation of the variables is poor, a higher correlation is not to be expected. The second part of the table 2 presents the results of Barlett's  $\chi^2$  test of sphericity, where a high significance (.000) shows that the correlation matrix is different from the system of matrices. In case there were no significances, it would mean that each variable was an independent factor and the utilization of multivariate analysis method would be disputed due to the lack of correlation among certain variables.

Table 3, under column 2, shows the constants, i.e. maximum values of common object of assessment which is 1. Column 3 shows the extraction value together with the common object of assessment for each manifest variable.

The next step of factorization has the relevant data in table 4, where the components and the value of characteristic roots are shown by the components. The same table shows the value of variance with the common object of assessment both individually and collectively. It is also worth mentioning that the standard criterion of the number of latent dimensions or factors,  $l \geq 1$ , has reproduced six of them.

Following the procedure of Varimax factor rotation, table 5 shows the relevant coefficients by factor in bold letters.

Scree Plot indicates a clear elbow at the meeting point of the third and fourth components. That means that the first three components account for a much larger proportion of the variance of the remaining components (Figure 1).

## DISCUSSION AND CONCLUSION

Based on the initial factor matrix, i.e. the numeric value of comunalities of the measured object labeled as *the basketball efficiency*, it can be

noticed that the basketball efficiency stands as real, and as general dimension, which is in this example determined by thirteen (13) observed manifest variables. The analysis of structure and value of comunalities draws a conclusion that the manifest variable comunalities for AFT, MFT, M3, A3, TO and A2 points are larger in number compared to the others. The personal fouls (PF) comunalities is slightly smaller, however. (table 1)

Here we find it necessary to point out that factor analysis is a research method, with interpretation of results and their utilization left as an author's discretion in terms of further processing; therefore, it is not to be seen as being subjected to any firm or strict statistical regulations. (Pallant, 2009),

Monitoring the acronyms and their meanings, the manifest indicators of basketball efficiency were spotted on the first factor: A3 (.910) and M3(.887). (Table 5) It is clear that this factor is defined by variables of three-points shot. It is also worth noting a negative projection of A2 (-.466) and M2 (-.450) onto this factor. Hence, this factor can be labeled as *three-points shot* factor.

The factor has appeared as stable in previous researches of the latent structure of basketball efficiency. Trninić et al. (1995), Sporiš et al. (2006) and Simović et al. (2010), have also isolated this factor with variables of M3 and A3.

The second factor is determined by the variables of AFT (.968) and MFT (.967). This factor, due to its structure, was labeled as *free throws factor*. It appears as stable at both the observed world championships and previous researches of latent structure of basketball efficiency. Considering the World Championship 1998, the second factor includes: MFT, AFT and PF. AT WC 2002 and 2006: MFT and AFT. It is also stable in the previous researches of: Trninić et al. (1995) PF, MFT and TO; Sporiš et al. (2006) MFT, AFT and PF; Šeparović and Nuhanović (2008) MFT, PF and AFT and Simović et al. (2010) MFT, AFT and PF.

The third factor is defined by the following variables: A2 (.741), OR (.734), M2 (.644) and ST (.591). It is evident that this factor is best defined by the variables of offensive efficiency, which entitles us to label it as *the factor of general offensive efficiency*. In the research conducted by Trninić et al. (1995) the latent structures of WC in Toronto,

the factor of general offensive efficiency was extracted and it was composed by the variables of AS, M2 and A2. Also, Simović et al. (2010) extracted this factor with the elements of its structure being the following factors: M2, A2, PST, TOTO and AS.

The fourth factor is accounted for by AS and BS. The fifth factor is saturated by the variance of DR and PF variables, while the sixth factor is saturated by the TO variable.

Respecting the mentioned criteria in all examples, we were able to extract six latent dimensions, i.e. factors. The extracted variance is 77.161%. Next,  $\lambda_1=2,690$  with the percentage of common variance at 20,692. Followed by  $\lambda_2=2,333$  and variance 17,944 and  $\lambda_3=1,681$  with the variance of 12,929, which is 51,566% taken cumulatively.

The factor analysis with six extracted latent dimensions and isolation of three components which account for a much larger proportion of the variance of the remaining components point to the fact that the latent structure of basketball efficiency at the Zone Championships in the year of 2009 can be explained by the following: three-points shot factor, free throws factor and the general offensive efficiency factor. As the structure of these factors is dominated by the variables which account for the total number of attempted shots (A2, A3 and AFT) and the total number of made shots (M2, M3 and MFT), and shots from different distances (ranges) – three-points shots, two-points shots and free throws – it can be concluded that the general latent structure of basketball efficiency is comprised by these factors. This is further backed up by the empirical and theoretic speculations of basketball experts, i.e. the overall basketball efficiency is primarily dependent on the shot efficiency. The same conclusion was derived in the researches of latent structure of basketball efficiency for the last four basketball World Championships in the paper composed by Simović et al. (2010).

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## ЛАТЕНТНА СТРУКТУРА ЗА ЕФИКАСНОСТА НА ЗОНСКИТЕ КОШАРКАРСКИ ПРВРНСТВА ВО 2009 ГОДИНА

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(Оригинален научн труд)

Слободан Симовиќ<sup>1</sup> и Ѓорѓе Ниќин<sup>2</sup>

<sup>1</sup>Универзитетот во Бања Лука, Факултетот за физичко воспитување и спорти,  
Бања Лука, Босна и Херцеговина

<sup>2</sup>Универзитетот „Алфа“, Белград, Факултетот за Менаџмент во спортиот,  
Белград, Србија

### Апстракт:

Со примена на Хоџелинговата (Hotelling) метода на главните компоненти, постоа со Варимакс (Varimax) ротацијата на главните компоненти според Кајзеровата (Kaiser) постапка, утврдена е латентната структура на кошаркарската ефикасност. За зонските првенства изолирани се шест главни компоненти за кои објаснетата варијанса изнесува 77,16%. Факторизацијата е изведена на примерок на сите победници, односно 220. Латентните димензии се добиени врз основа на 13 параметри на ефикасноста. Факторската анализа со шест екстрахирани латентни димензии, и со издвојување на три компоненти кои објаснуваат поголем дел на варијансата од другите компоненти, укажа на тоа дека латентната структура на кошаркарската ефикасност на Зонските сениорски првенства во 2009 година, може да се објасни: со факторот на уфрлувањето за три поени, факторот на изведувањето на слободните фрлања и факторот на оштетата ефикасност за напад.

**Клучни зборови:** ФИБА, ситуациони варијабли, факторска анализа