The latent structure of standard game efficiency indicators in basketball.

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Abstract

This study defines the latent structure of standard indicators of situational efficiency in the game of basketball. Data was collected from 134 basketball matches played in the regional Goodyear League 2002/03 season. The sample of variables included 13 standard situational efficiency indicators recorded during a basketball match. The (Factorial) principle components method was employed and the number of significant factors was determined using the Guttman-Kaiser Criterion. The initial co-ordinate system was transformed through a non-orthogonal rotation according to the Oblimin criterion. Six inter-independent latent dimensions explaining 67.5 % of total variance were determined: basic offensive efficiency, the three-point play, errors in posting the defense and realisation from the free throw line, defensive agressivness on the player in possession of the ball and offensive agressivness of the player in possession of the ball, basic defensive efficiency and defensive/offensive back line efficiency.

The obtained latent structure provided good interpretation of the continuance and functional dependence of 13 standardised indicators of player performance. However, these indicators are considered inadequate for explaining the complexity of the game. Additional player performance indicators should be included in future scientific analysis.

Keywords: Basketball, factor analysis, latent structure

1. Introduction

Basketball is a complex team sport in which the basic aim is to score more points than the opposing side through constant alternations between offensive and defensive play. There exists a need for a more qualitative and exact description of these specific phases of the game, the individual player and/or team. The opportunity for analysing situational efficiency indicators as well as tactical responsibility and player activity parameters arises through adequate conduction of game statistics (Trninić, 1996). By analysing situational efficiency indicators it is possible to derive model values of team efficiency and individual player performance in defense and offense, as well as a comparison of players and teams, which is important for more efficient programming of the preparation process (Milanović et al. 1993).

Trninić (1975) investigated the correlation between defensive and offensive rebounds and the final score and asserted an insignificant correlation between the two. The study was carried out on a sample of 25 basketball matches in the Championship of Yugoslavia.

Milanović (1978) applied regression analysis to a sample of 26 basketball matches in the Championship of Yugoslavia and determined a significant correlation between the following variables: *shooting accuracy from various distances* and *winning in basketball*, in particular *shooting from a distance, lay ups,* and *dunks.*

Pleslić (1994) investigated the influence of 14 basketball elements on the final game score and found a significant positive correlation between the following variables: *scoring a goal under the basket from half-distance, from the free throw line* and *steals* and *final game score*. A negative correlation was asserted between the variables: *turnovers* and *final game score*. The study was carried out on a sample of 20 basketball matches in the 1989 European Championship played in Zagreb.

Trninić et al. (1995) investigated the impact of offensive and defensive rebounds and found that these elements have a significant influence on the final game score. Their conclusion was that the variable, *defensive rebounds,* provides a better distinction between the winning and losing team. The study was carried out on a sample of 64 basketball matches in the 1994 World Championship played in Toronto. In this particular sample, Trninić et al. (1995) found a latent structure of manifest variables. Four relatively independent latent dimensions were isolated and named: *back defensive line and front offensive line player efficiency, front defensive and back offensive line player efficiency, general offense efficiency* and *efficiency of goal scoring from a distance*. The authors concluded that neither the 13 standard situational efficiency indicators nor the latent dimensions derived from them are sufficient to fully explain the structure of the basketball game.

Dizdar (1997) presented a methodological procedure for the analysis of relations between a cluster of independent variables (predictors) and a dependent variable (criterion) in such specific situations in which the predictors are influenced by additional factors. He concluded that the proposed regression model could be the one to define the relation between situational variables and the final game score in more depth and detail. Klasić (2000) investigated the differences between winning and losing teams, Cibona and Zadar, in the 1999/2000 season by analysing standard situational efficiency indicators. He concluded that standard indicators made a good distinction between the teams, especially the following: *number of field goals made, number of defensive rebounds, number of assists* and *steals*. The study was carried out on a sample of 7 basketball matches.

The latent structure of standard situational efficiency indicators has also been investigated in other sporting disciplines. Janković (1988) defined the latent structure of technical-tactical elements in volleyball. Using the componential model with Guttman-Kaiser Criterion he extracted four major components: *general efficiency, setting efficiency, efficiency in executing elements in the back line* and *offense efficiency*. Vuleta et al. (1999) found a latent structure of 134 manifest technical-tactical activity indicators in handball. Using the componential model of factor analysis, five significant factors were extracted, three of which contained sufficient interpretative data: *offense efficiency, defense efficiency* and *goalkeeper efficiency*.

Specific competition qualities and small samples in previous studies, that defy the generalisation of the problem, are a possible reason for the manifestation of various inter-correlations between standard situational efficiency indicators, but also of varied correlations between indicators and the final game score. Nonstandard game conditions challenge the quality of standard situational efficiency indicators as an instrument of measurement. The influence of referees, spectators, various opponents or playing fields (home or away) changes measuring conditions and goes against the requirements of the measurement theory (Brčić et al., 1997). Conducting the study on a sufficient sample increases the quality of standard situational efficiency indicators as an instrument of measurement.

The standard situational efficiency indicators used in this study provided a precise quality description of the offense and defense. Offense was explained using the following indicators: *two-point field goals, three-point field goals, goals from the free-throw line, offensive rebounds, assists* and *turnovers*. Defense was described using *defensive rebounds* and *steals*. The indicator *personal fouls* appeared in both offense and defense. These indicators have been standardised by the International Basketball Federation (FIBA).

2. Methods

2.1 Subject sample

The data was collected across 134 basketball matches played during in-season league and finals in the regional Goodyear League 2002/03 season. Twelve teams entered the competition. 131 matches were played in league season (22 rounds comprising six matches each, one match cancelled). In the finals, four teams qualified and played 3 matches (semi-finals and final match).

2.2 Sample of variables

The sample of variables consisted of 13 standard situational efficiency indicators recorded for each team during the game:

1. TWO-POINT FIELD GOALS - SUCCESFUL (TPFG_2_S) – the number of successful shots thrown from within an area of 6.25m from the basket.
2. TWO-POINT FIELD GOALS - UNSUCCESFUL (TPFG_2_U) – the number of unsuccessful shots thrown from within an area of 6.25m from the basket.
3. THREE-POINT FIELD GOALS - SUCCESFUL (TPFG_3_S) – the number of successful shots thrown from outside an area of 6.25m from the basket.
4. THREE-POINT FIELD GOALS - UNSUCCESFUL (TPFG_3_U) – the number of unsuccessful shots thrown from outside an area of 6.25m from the basket.
5. FREE-THROWS - MADE (FT_S) – the number of goals scored from the free-throw line.
6. FREE THROWS - MISSED (FT_M) – the number of missed shots thrown from the free-throw line.
7. OFFENSIVE REBOUNDS (OFR) – the number of balls caught after rebounding off the hoop or backboard during the offense game.
8. DEFENSIVE REBOUNDS (DER) – the number of balls caught after rebounding off the hoop or backboard during the defense game.
9. ASSISTS (AS) – the number of balls passed between teammates enabling goal scoring.
10. TURNOVERS (TR) – the number of balls lost in offense.
11. STEALS (ST) – the number of balls won in defense.
12. PERSONAL FOULS (PF) – the number of fouls made by a player in offense and defense involving physical contact.
13. BLOCKED SHOTS (BS) – the number of blocked or parried shots performed during transitional or set defense.

The data was sourced from official statistics managed by expert statisticians. The official Goodyear League internet website (www.goodyear.adriaticbasket.com) was used as a data resource.

2.3 Data processing methods

In our research we employed exploratory factor analysis to determine the fundamental latent dimensions i.e. sources of variations and co-variations between variables. Factors were extracted using the principle components method. The number of significant factors was determined by means of the Guttman-Kaiser criterion. The initial coordinate system was transformed through a non-orthogonal rotation according to the OBLIMIN criterion (Fulgosi, 1988).
The following was computed:

- basic statistical parameters (mean, minimum and maximum results, standard deviation, coefficient of variability, degree of asymmetry and warp degree)
- the Kolmogorov-Smirnov test for testing distribution normality
- characteristic square root of extracted factors
- factor structure matrix

The data were processed using SPSS 13.0 for Windows.

3. Results

Basic statistical parameters (Table 1.) represent average values of standard situational efficiency indicators and minimum and maximum match values.

Table 1. Basic statistical parameters.

	mean	min	max	Std.Dev.	skewness	kurtosis	variability	max D
TPFG_2_S	21.97	9.00	38.00	4.79	0.28	0.35	21.8%	0.07
TPFG_2_U	16.90	5.00	37.00	5.19	0.58	0.66	30.7%	0.09
TPFG_3_S	6.86	0.00	16.00	3.08	0.35	0.20	44.9%	0.09
TPFG_3_U	12.74	3.00	28.00	4.23	0.58	0.72	33.2%	0.07
FT_S	17.72	5.00	38.00	6.14	0.57	0.19	34.6%	0.09
FT_M	6.26	0.00	20.00	3.30	0.78	0.99	52.7%	0.10
OFR	8.14	1.00	19.00	3.36	0.35	-0.13	41.3%	0.09
DFR	18.91	4.00	33.00	4.89	0.04	0.22	25.9%	0.06
AS	11.77	1.00	34.00	5.46	0.79	1.20	46.4%	0.10
TR	23.87	4.00	38.00	4.41	-0.14	1.29	18.5%	0.06
ST	13.76	5.00	27.00	3.87	0.21	-0.15	28.1%	0.07
PF	8.90	0.00	22.00	4.09	0.53	-0.11	46.0%	0.09
BS	1.84	0.00	8.00	1.58	0.90	0.73	86.2%	0.18

The standard situational efficiency indicator, BLOCKED SHOTS (BS), varied significantly from normal distribution with a very distinctive variability coefficient of 86.2%. The indicator (BS) did not differ significantly between winning and losing teams, i.e. making no significant distinction between the two groups. A wide range and high coefficient of variability was observed in the following indicators: ASSISTS, FREE THROWS - MISSED, STEALS AND THREE-POINT FIELD GOALS - SUCCESSFUL.

From a total of 78 correlations, 28 (35%) were statistically significant. The highest correlation was registered between variables defining two or three-point shot efficiency, and the correlation between ASSISTS and TWO-POINT SHOTS (r=0.45). The high correlation between these two variables is apparent as after every assist a realisation is necessary, but not the other way around. Every shot need not be preceded by an assist. A high correlation was registered between offensive rebounds and unsuccessful shots, particulary unsuccessful two-point shots (r=0.46).

Table 3. Rebound efficiency of winning and losing teams.

	WIN	*LOSS*	
OFR	8	8.27	OFR – offensive rebounds
DFR	20.3	17.5	DFR – defensive rebounds
TOTR	28.3	25.77	TOTR – total rebounds
SHMI	33.71	37.97	SHMI – shots missed
OFRE	23.70%	21.78%	OFRE[1] – offensive rebound efficiency
DFRE	53.46%	51.91%	DFRE[2] – defensive rebound efficiency
TRE	39.48%	35.95%	TRE – total rebound efficiency

[1]Offensive rebound efficiency is derived as a proportion of missed shots and offensive rebounds of a team , expressed as a percentage.
[2]Defensive rebound efficiency is derived as a proportion of missed shots of one team and the defensive rebounds of the opponent , expressed as a percentage.

Six factors were extracted from the cross-correlation martix using the principle components method.

Table 4. Characteristic root values of isolated factors.

	Eigenval	*Variance %*	*Eigenval cum.*	*Cum. %*
Factor 1	1.87	14.41	1.87	14.41
Factor 2	1.78	13.69	3.65	28.10
Factor 3	1.50	11.57	5.16	39.67
Factor 4	1.41	10.81	6.56	50.48
Factor 5	1.20	9.23	7.76	59.72
Factor 6	1.02	7.81	8.78	67.52

No significant correlation was found between these factors.

Table 5. Factor structure matrix.

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**
TPFG_2_S	**0.76**	0.40	-0.07	-0.04	0.11	0.18
TPFG_2_U	-0.224	0.24	-0.14	**0.82**	-0.02	-0.07
TPFG_3_S	0.136	**-0.74**	-0.07	-0.28	-0.23	-0.19
TPFG_3_U	-0.098	**-0.80**	0.04	0.10	0.01	0.13
FT_S	-0.24	0.16	**0.70**	-0.15	-0.15	0.16
FT_M	0.02	0.05	**0.69**	0.19	0.28	-0.13
OFR	0.03	-0.17	0.19	**0.82**	-0.09	0.14
DER	0.12	0.00	-0.04	-0.05	-0.20	**0.78**
AS	**0.83**	-0.16	-0.02	-0.12	-0.02	0.19
TR	0.10	-0.21	**0.66**	0.03	-0.08	-0.25
ST	-0.24	0.31	-0.05	-0.11	**0.64**	0.15
PF	0.17	-0.08	0.06	0.03	**0.80**	-0.14
BS	0.21	-0.02	-0.17	0.14	0.22	**0.60**

4. Discussion

The first latent dimension was correlated with manifest variables TPFG_2_S and AS (both of which had a high inter-correlation (r=0.45) (Table 5.). This factor explains most of the total variance (14.41%). Among other influencing factors, team offense is determined by so-called *point-guard play* defining the role of a playmaker. A player in this particular position is bound to have high ball manipulation abilities, highly developed catching and passing skills and a capability of penetrating the front defensive line (Trninić, 1996). Penetration of the front defensive line often ends with a simple realisation called the *easy basket* causing a high percentage of two-point shots. Alternatively, if weak side-help occurs, passing the ball to execute a successful action from under the basket or half-distance will follow. Disciplined offensive play involving specifically assigned responsibilities (screening, maintaining the court area and court balance) and continuous monitoring of defense positions enables offensive players to execute inside and outside passes accurately and on time. Most often this leads to a clear shot or scoring from under the basket. The variables describing this latent dimension speak clearly of a factor we can name *basic offensive efficiency*.

The second latent dimension was correlated with variables TPFG_3_S and TPFG_3_U. The inter-correlation between these variables (r=-0.27) was statistically significant. This factor explained 13.69% of total variance. It appears that there are more and more players with an ability to successfully score from long distances. Excluding outside players, tall players who can successfully execute shots from outside positions and create the opportunity for fast outside players to penetrate the area under the basket or to assist after penetrating the front defense line to score two or three-point field goals, are greatly sought after. This is confirmed by the percentage of total variance occupied by this factor (correlation coefficient of the variable TPFG_2_S with the latent dimension was r=0.40). In line with this, following the penetration, thanks to good defense, loss of ball possession often occurs as a result of unsuccessful passes or some other error on offense. This was confirmed by a lower percentage of total variance occupied by this factor. The name of this factor is as follows - *three-point play factor*.

The third latent dimension had a high correlation with the following variables: FT_S, FT_M and TR. This factor explained 11.57% of total variance. Correlation between these variables was statistically significant, ranging from 0.19 to 0.26. Personal fouls are often a result of defensive play in which irregular hand use dominates over the role of the body and footwork, errors in controlling the defensive positions, poor timing on part of the help side, "switching" or double teaming. An early enterance of the bonus means that every subsequent personal foul is fined with a free-throw. This increases functional dependence between the two situational efficiency indicators. This factor can be named the *factor of errors in posting the defense and realisation from the free-throw line*.

The fourth latent dimension was highly correlated with the variables TPFG_2_U and OFR. This factor explained 10.81% of total variance. An inter-correlation of 0.46 between these two variables was statistically significant. This emerged from the fact that a higher number of missed shots lead to a higher number of offensive rebounds (Table 3.). The high impact on the ball, when in an outside position, makes inside passes more difficult. This leads to a situation in which the ball is caught in an unfavorable condition for the realisation of an action, i.e. enabling a more qualitative defense in a "one-on-one" situation or when double-teaming and rotating the defense. As a result, short passes within the post area and passes for shots from half-distance are limited. Conversely, in terms of actions used to defend the fast break, during a fast break, the tendency for inside plays is justified by the prolonged activity following the shot; by the offensive rebound. This factor can be defined as *the factor of the defensive back line efficiency and offensive back line efficiency.*

The fifth latent dimension was correlated with variables ST and PF. Steals have always been a result of aggressive defensive play, i.e. the decreased ability of the offensive player to adapt to such play. The impact on the ball and pass lines makes timing and pass accuracy impossible and more difficult; often leading to ball steals. At the same time, such defensive play enables a large number of brisk and attractive realisations. What emerges is that overly aggressive defensive actions on the player in possession of the ball could lead to an easy disturbance of defensive balance and penetration of the first line of defense. This factor could be named as *the factor of the defensive agressivness on the player with the ball and the offensive agressivness of the player with the ball.*

Variables DFR and BS were correlated with the sixth latent dimension. Inter-correlation of these two variables was statistically significant, but rather small (0.16). This correlation occurred due to the fact that quality teams have a powerful center rebound line and, in addition to a large number of defensive rebounds, they possess extra quality as shot blockers. The defensive rebound is essential for all teams to build on the way to victory (Trninić, 1995). It also represents the first phase of the fast break and a result of successful individual or team defense, communication and screening. The block-shot is also a result of successful individual or team defense. In most cases this parameter is an exclusive entitlement of tall players and players with developed explosive strength, the right sense for rebounds and block-shots. The block-shot can also be the result of quality team efficiency, where the player monitors the game during the second or third pass and blocks the opponent's shot. This factor was given a lesser variance percentage by the variable TR (-0.25). It is understood that every successful defense stops their opponent's fast breaks by way of so called tactical personal fouls outside the shooting area. Coaches expecting high performance from their teams are aware that the number of easy baskets has to be brought down, even at a price of personal fouls. Special emphasis is placed on the introductory part of the quarter, while the team still hasn't reached the bonus. Some coaches feel that the first four personal fouls are bound to be "tactical" personal fouls. In conclusion, this factor can be named *the factor of basic defensive efficiency*.

5. Conclusions

The primary objective of this study is to determine the latent structure of standard indicators of situational efficiency in the game of basketball, namely, the sources of variations and co-variations between variables. Exploratory factor analysis was employed to determine this.

Nonstandard conditions, in which the basketball match is played, dispute the quality of standard situational efficiency indicators as an instrument of measurement. It is in the authors' opinion that by increasing the subject sample, the quality of standard situational efficiency indicators as a measuring instrument will increase.

Factors were extracted using the principle components method and the number of significant factors was determined by means of Guttman-Kaiser Criterion. The initial co-ordinate system was transformed through a non-orthogonal rotation according to the OBLIMIN criterion (Fulgosi, 1988.). The subject sample consisted of 134 matches played during the regional Goodyear League 2002/03 season. The sample of variables comprised of 13 standard situational efficiency indicators registered during matches by official statisticians. Six latent dimensions explaining 67.53% of total variability were isolated. The extracted factors were named: *basic offensive efficiency, the three-point play, errors in posting the defense and realisation from the free throw line, defensive agressivness on the player in possession of the ball and offensive agressivness of the player in possession of the ball, basic defensive efficiency* and *defensive/offensive back line efficiency*.

The latent structure of standard situational efficiency indicators obtained in this study explained 22.1% more total variability variance of manifest variables compared to that of the previous study (Trninić et al. 1995) providing a more exact analysis of the game of basketball. This is explained by the use of a larger subject sample increasing the reliability of the study and reducing analysis error. The obtained latent structure allowed solid interpretation of the correlation and functional interdependency of the 13 standard situational efficiency indicators. The authors believe that that aforementioned indicators are not sufficient for the interpretation of the complexity of the basketball game and that studies with additional situational efficiency indicators should be carried out.

6. References

Brčić, B., Viskić-Štalec,N.,& Jaklinović-Fressl, Ž. (1997). Predictive Value of Variables for Evaluation of Technical-Tactical Elements in Handball. *Kinesiology*, 29 (1), 60-70.

Dizdar, D. (1997). Assessing One Methodological Procedure for the Evaluation of Sport Results. (Masters Thesis), Faculty of Physical Education, University of Zagreb.

Fulgosi, A. (1988). *Factor Analysis*. In Croatian. Zagreb: Školska knjiga.

Janković, V.(1988). Latent Structure of Technical-Tactical Elements in the Game of Volleyball. *Kineziology*, 20 (1):57-62.

Klasić, S. (2000). Standard Situational Efficiency Indicators in Games Between Cibona and Zadar – season 1999./2000. (Graduated thesis), Zagreb: Faculty of Physical Education, University of Zagreb.

Milanović, D. (1979). Influence of Score-related Variables on the Final Score in Basketball. *Kineziology*, 9 (1-2): 135-149.

Milanović, D. (1997). Fundamentals of Sports Training. In D. Milanović (Ed.), Handbook for sports coaches. Zagreb: Faculty of Physical Education, University of Zagreb.

Pleslić, D. (1994). Influence of Basketball Elements on the Final Game Score. (Graduate Thesis) Faculty of Physical Education, University of Zagreb.

Trninić, S. (1975) Correlation Analysis between the Frequency of Defensive and Offensive Rebounds and the final result in a Basketball Game. (Graduate thesis), Faculty of Physical Education, University of Zagreb.

Trninić, S., N. Viskić-Štalec, J. Štalec, D. Dizdar I Ž. Birkić (1995). Latent Structure of Standard Situational Efficiency Indicators in the Game of Basketball. *Kineziology*, 27 (1): 27-37.

Trninić, S., D. Milanović, M. Blašković, Ž. Birkić I D. Dizdar (1995). The Influence of Defensive and Offensive Rebounds on the Final Game Score. *Kineziology*, 27 (2): 44-49.

Trninić, S. (1996). Analysis and Teaching of the Game of Basketball. Pula: Vikta.

Vuleta D., Milanović, D., Sertić, H. (1999). Latent Structure of Spatial, Phasic, Positional and Movement Characteristics of Handball. *Kineziology*, 31 (1): 35 – 50.

Vuleta, D., Milanović, D. I Sertić, H. (2003). Relations Between Variables of Shooting for a Goal and Outcomes in the 2000 Men's European Handball Championship matches. *Kineziology*, 35 (2): 168-183