# Developing Basketball Game Strategy through Statistical Analysis

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# Abstract

Management style tends to vary according to either manager’s intuition or analytical and objective reasoning. Sports and, particularly, basketball can be considered as an indicative field where these differences in decision making can be found. This paper has been motivated by the authentic statistical analysis that the author conducted in the past in order to support the management of a Greek basketball team and specifically the decision making process of their coach regarding the team’s strategy in their games. The aim of the paper is on the one hand to present some indicative, simple ideas for the statistical analysis of basketball data, and on the other hand to show that any basketball team can improve significantly its decision making process if it chooses to be statistically supported. Basketball data is numerous; consequently its elaboration can be extensive and fruitful.

**Key words**: Basketball; Operations research; Statistical analysis; Regression models; IRAKLIS

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# Introduction

Management and decision making process can be either intuitive, i.e. more subjective and spontaneous, or based on data, indexes, statistical analysis and, generally, quantitative methods of operational research (OR). The dilemma of choosing the appropriate management strategy is found in any type of operation where management decisions have to be made. The specific belief has been endorsed by many researchers, from various research areas: Brunswik (1956) was the first who suggested that decisions can be made either in an intuitive or an analytical mode. Since then, management styles were further studied by many others, such as Hammond (1988), Calori et al. (1995), Dunwoody et al. (2000), Khatri and Ng (2000) etc.

Sports and, particularly, basketball can be considered as an indicative field where several management decisions are taken every day. However, mainly depending on the country and the popularity of basketball, these decisions and, more precisely, the part of them referring to the game strategy are made more or less intuitively. For example, basketball in the U.S. and particularly in its major representative, the NBA, is strongly supported by the collection and the statistical analysis of various data, as well as quantitative techniques. See for instance Mike Zarren who is on Boston Celtics’ payroll and holds the title of Assistant General Manager/Associate Team Counsel[[1]](#footnote-1). He assists the team by evaluating potential trades and draft picks, and offers strategic advice to coach Doc Rivers (Dubner and Levitt, 2008). The U.S. basketball world has realized that sports constitute a business where a lot of money is at stake, therefore there is no room for managers’ … inspirations to rule hundreds of millions of dollars.

On the contrary, despite the popularity of basketball in Europe (which, however, is lower than the one in the U.S.), basketball is mainly managed by the so called “experienced” people, who usually believe that they do not need further help from indexes and statistics in order to make the necessary decisions. For instance, consider Greece where basketball is the second most popular sport after soccer. Nevertheless, this popularity does not help the people involved in teams’ management realize that a lot of money can be won or lost depending on the type of management they adopt and the quality of decisions they make. Consequently, the “experience” and the … unmistakable “feeling” are thought to be enough for managers to optimize their decisions!

Perhaps it is not absolutely fair to consider this managerial behavior as an irrationality of the sports’ field exclusively; the same tendency can be noticed in almost every business activity of Greece (as well as Spain, Italy and most of the South European countries). Most of the times managers in these countries do not use statistics, quantitative methods and OR, in order to optimize their decisions. This happens mostly because

* even *if they know how to apply quantitative methods and OR* the specific way of management is time consuming; usually businessmen and executives ask everybody in their payroll to … “run” - no matter if they do not know where to run to - and not to “waste” their time trying to implement optimized techniques,
* while *if they do not know how to apply quantitative methods and OR* hiring consultants to train the company’s managers and/or solve the company’s managerial problem(s) would cost a lot! As a result, businessmen are interested in this type of external help only if they manage to ensure an EU funding program.

On the other hand, Germany, England, France etc. have pushed forward OR methods in the decision making process of their companies. Nevertheless, as far as basketball is concerned most North Europeans believe that … they have better things to do in their leisure time, i.e. the popularity of basketball is very low. Therefore, the majority of people who are actively involved in basketball have come to perceive it mainly as a hobby and not as a professional activity that attracts the interest of the crowds. Apparently, nobody needs OR and statistics to practise a hobby!

Choosing between an intuitive or an OR supported decision-making process has to do with not only basketball coaching staff, but also with all management executives who are involved in a team’s management, e.g. the owner, the president and the members of board, the general managers, etc. However, this paper focuses particularly on coaches who take instantaneously numerous crucial decisions regarding the outcome of a basketball game. This is their additional difficulty in comparison with all the others who usually have plenty of time to make a decision on every issue that influences the progress of the basketball team they work for. Moreover, it seems absolutely normal to all of us to watch coaches make intuitive decisions regarding their team’s strategy in a game, the player substitutions, the team’s tempo etc. But is this way of making decisions the optimal one?

The aim of this paper is to present some simple ideas to analyze basketball data, as well as to show that even simple descriptive statistics can be very helpful in supporting the decision making process of any coach both before as well as during a basketball game. The assessment through regression analysis that we present substantiates this claim. Moreover, our study aims to show that a basketball team can benefit greatly if it chooses to be statistically supported. Basketball data is numerous, thus its elaboration can be extensive. Therefore, after the literature review of Section 2, we present in Section 3 an indicative part of an authentic statistical report that the author (who will be referred to as “statistical analyst” – SA, hereafter) was preparing on a weekly basis, in 1999 to support the Greek basketball team of IRAKLIS and, specifically, its coach at that period, Dragan Sakota. In Section 4, we evaluate the conclusions of the authentic statistical report using regression models, while in Section 5 we present some additional statistical and OR techniques which could be considered as interesting directions for future research. In Section 5 we discuss the response of basketball coaches to the statistical support of the decision making process and, finally, we present some useful conclusions in Section 5.

Regarding the team that this report refers to, i.e. IRAKLIS ([www.iraklisbc.gr](http://www.iraklisbc.gr)), we should mention that it is a historic basketball club from Thessaloniki, Northern Greece. Founded in 1908, IRAKLIS was the first club to win the national title in 1927-1928 and has also won the league in 1934-1935. One of its earliest players, Abatzioglou, was one of the 13 founders of FIBA. IRAKLIS has participated twice in the European Euroleague (1996 European Championship and 2001 FIBA Suproleague). Many famous basketball players have played for IRAKLIS, like X-MAN McDaniels, Jury Zdovdc, James Donaldson, Walter Berry, as well as the very popular Greek stars Dimitris Diamantidis, Sofoklis Shortsianitis, Lazaros Papadopoulos, Nikos Chatzivretas, Lefteris Kakiousis, who have also been successful members of the Greek national basketball team all these years.

On the other hand, Dragan Sakota (who will be called “coach” hereafter) is one of the most important Serbian basketball coaches. He coached several European clubs like Crvena Zvezda (Serbia & Montenegro), Zadar, Cibona (Yugoslavia), and PAOK, *IRAKLIS*, Aris, Olympiakos (Greece), while he was the assistant coach of Serbia & Montenegro National Team in 2004 and the head coach of the same team in 2006.

# Literature review

Nowadays, quantitative methods and techniques that can be used to improve decision making in sports and specifically in basketball, present a growing popularity. Oliver (2004) makes a significant contribution regarding the use of statistics in conducting basketball performance analysis. Among the various issues that he addresses, special interest can be found in his references on i) the normal distribution of data (Chapter 11), ii) the insights on a box score (Chapter 16), iii) the various tools that can be used for a team evaluation (Chapter 23) and iv) the multivariate regression of basketball data (Appendix 4). On the other hand, Albert et al. (2005) collect previously published articles on the use of statistics to analyze sports. Their book contains separate sections devoted to the major team sports, i.e., baseball, football, basketball and ice hockey. Winston (2009), who devotes a great part of his book on basketball, intends to introduce the reader to various models that are used to analyze sports. He notices that some of these models are used in practice by team management to aid in the decision making process. Berri and Schmidt (2010) are inspired by the fact that people generally have trouble making “good” decisions. Based on experimental evidence they present various stories which, they claim, should not only change the way sports fans perceive the choices made by their favorite teams, but also impact the way economists and other social scientists think about human decision-making. Special interest can be found in their Appendix A where they measure wins made in the NBA through regression analysis. The book of Berri and Schmidt (2010) can be considered as an extension of the one of Berri et al (2006) who admit that despite the fact that sports are played every day and numbers are recorded continuously, those numbers are poorly understood. Thus, through their book they actually make an effort to change the general picture.

As far as published articles on this area are concerned, the paper of Zak et al. (1979) should be included among the most important ones; they estimate a production function for basketball teams and they apply it to data collected during the 1976-1977 NBA season. Their purpose is to examine the determinants of a team’s performance. Many years later Schwertman et al. (1991) use the NCAA regional tournament as a great opportunity to apply probabilistic concepts. This way they develop an educational probability exercise. Ghosh and Steckel (1993) analyze playing statistics for two different seasons and classify NBA players as scorers, bangers, dishers etc. Their analysis of a team's role structure provides useful guidelines for selecting draft choices and executing trades. Kwam and Sokol (2006) present a model that predicts NCAA tournament outcome more effectively than standard ranking and rating systems, while it requires only basic input data. More specifically they present a model for ranking college basketball teams and for estimating win probabilities. Berri et al (2007) reexamine several pieces of evidence previously presented in the literature, demonstrating that decision makers in the NBA do not process information efficiently. They also present two empirical models which have been initially described in less detail in Berri et al. (2006). Finally, Kubatko et al. (2007) present some generally accepted basic variables of basketball analysis, thereby providing a common starting point for future research in basketball.

Moreover, there are a lot of papers regarding many other managerial issues, which go beyond the competing part of basketball. For instance, Bean and Birge (1980) considering that the 22 teams of NBA (at that time) travel an unnecessary number of airline miles, consider several optimization methods to lower the total number of passenger miles the league travelled. They manage to develop efficient schedules which would lead in practice to savings of 757,000 $ or 20.4% over the NBA's current schedule. On the other hand Morse et al. (2008) examine through a regression equation the effects of roster turnover on season attendance in the NBA, over a five-year period (2000-2005).

Finally, the latest developments in basketball, not only in the NBA but also in other advanced countries should not be ignored; several teams employ statistical analysis especially for player recruitment. For example, Popp et al. (2010) admit that player recruitment is both intense and expensive as coaches must recognize talent at an early age and from a broad geographic range. In their study they try to determine which factors are the most influential when international student-athletes choose to attend US universities. Moreover, they statistically compare such influences with those of domestic student-athletes to determine if significant differences exist between the two groups. Sampaio et al. (2006) examine the differences in game-related statistics between basketball guards, forwards and centers playing in three professional leagues. They claim that the knowledge of these differences could allow the coaches to increase the effectiveness of the player recruitment process.

# The authentic statistical report

The statistical analysis support provided to IRAKLIS coaching staff was based on a short (approximately ten-page) booklet that SA prepared in the middle of every week, i.e. around Wednesday morning. This way, the coach had enough time to study the report and prepare his team accordingly, ahead of the championship game that was held on Saturday afternoon[[2]](#footnote-2). Moreover, every Wednesday a meeting took place between the SA and the coach, in order for the first to present and explain the main points of his analysis to the coach and his assistants. Wednesday’s meeting was also a chance for both parts to talk about any additional ideas which could be included in the statistical analysis the following week(s).

The statistical analysis was usually divided into four parts: the *first* one was about the performance of IRAKLIS during all previous games of the championship of 1999-2000, while the *second* part was about the performance of IRAKLIS’ opponents in the specific series of games. The *third* part referred to the performance and the characteristics of the players of the forthcoming opponent (namely, in our case, Maroussi). The *fourth* part of the statistical analysis was about the performance and the statistical data of the players of IRAKLIS’ forthcoming opponent in the previous championship (in our case during the championship of 1998-1999), either these players were in the same team or in a different one.

Based on Table 1 and Figure 1, SA presented the performance of IRAKLIS during the first six games of the championship. More specifically SA pointed out the following:

1. “*IRAKLIS scored three times more than 75 points and managed to win the game*”.

The usefulness of this remark for IRAKLIS’ coach arose from the fact that considering stable his team’s defensive performance, the offense was the one that determined mostly the outcome of a game. The interesting thing about this comment was the amount of points IRAKLIS had to score in order to win a game. In other words, for a different team this amount of points could be more, for example 85 points or for an even better defensive team than IRAKLIS less, for example only 65 points. Obviously, SA did not … reveal that when a team scores more it tends to win. However, even that simple conclusion can be very useful to be extracted through statistics, in order to strengthen them, enhance their value and unfold their ability to help the management of teams. Coaches (presidents, managers etc.) who are unfamiliar with statistics need first to be persuaded about the usefulness of statistics so they can later benefit from their use.

1. “*During the 6th game (against Dafni), the number of free throw (1p) attempts reached for the first time in that championship a very high level, namely 19 free throws, in an away game. In the other two games where IRAKLIS was a visitor, namely against Near East and AEK, the number of 1p attempts was only 10 per game. Obviously, a similar remark can be made about the earned fouls*”.
2. “*The 3p percentage of IRAKLIS is probably the statistical category that is connected so closely with the outcome of a game: whenever IRAKLIS outgoes 45% in 3p percentage, its team wins the game*”.

SA underlined that the players of IRAKLIS by paying attention to the “quality” of 3p shots they attempt, increase the potential of their team to be the winner of a game.

1. “*In four (out of six) games so far, IRAKLIS attempted 19 to 20 3p shots. This fact is indicative of the team’s propensity*”.
2. “*From Figure 1, it is easy to notice:*
   * *the increasing number of IRAKLIS total rebounds* (Figure 1a)*,*
   * *the progressively increasing number of turnovers* (Figure 1b) *and*
   * *the stability in the number of assists: from 11 to 14 per game (with just one exception* - Figure 1c*)*”.

### Table 1 about here

### Figure 1 about here

Regarding points ii, iv and v above, IRAKLIS’ coach had to account for the specific team behavior and encourage his players to repeat any positive strategy, while avoiding any negative one.

In Table 2 SA analyzed the performance of IRAKLIS’ opponents during the first six games of the 1999-2000 championship. His objective was to help the coach figure out how IRAKLIS’ playing style affected the opponents’ performance, as well as locate any good tactics and try to improve any damaging ones. More specifically, SA pointed out the following remarks:

1. “*IRAKLIS managed to reinforce its stable defense performance in the last game of the championship, by allowing Dafni to score only 59 points. This was IRAKLIS best achievement this season, which improved its already excellent defensive performance: in the previous five games of the championship its opponents scored between 67 to72 points*” (Figure 2a).
2. “*Although during the first five games of the championship the number of 3p attempts per game of its opponents was almost stable (around 11-12 shots), against Dafni this number increased significantly (16 attempts)*”.

SA claimed that the extremely low 3p percentage of Dafni (18.8%) justified IRAKLIS’ choice to “allow” (truly?) its opponent to attempt so many 3p shots.

1. “*The distinctive increasing number of IRAKLIS (total) rebounds (mentioned previously) is combined with the constantly decreasing number of its opponents’ rebounds*” (Figure 2b).
2. “*Excluding only one game, namely the one against Panionios, IRAKLIS lets its opponents have a constant number of approximately 10 assists*” (Figure 2c).

### Table 2 about here

### Figure 2 about here

Once again, regarding points vi, viii and ix mentioned previously, the coach had to figure out the remarks of SA, interpret the specific team behavior and manage to induce his players to repeat any positive tactics.

The third part of the statistical analysis referred typically to the performance and the characteristics of the players of IRAKLIS’ forthcoming opponent. Based on a simple box score of all the games played by the opponent until the moment of the statistical analysis (such as the one presented in Table 3) and the following simple equations, a more sophisticated table (such as Table 5) was created every week. More specifically, SA considered the following formulas (using the notation presented in Table 4):

 (1)

 (2)

 (3)

 (4)

 (5)

 (6)

. (7)

### Table 3 about here

### Table 4 about here

### Table 5 about here

In our study, considering the number of games played by each Maroussi player during the interval of the first six games of the Greek championship, and the average playing time of each player per game, SA pointed out that “t*he two American players play almost throughout every game of their team: Amaya (35.7 min per game*[[3]](#footnote-3)*) and Turner (35.2 min per game). Moreover, Maroussi coach usually prefers Korfas (26.2 min per game) and Panagiotarakos (21.3 min per game) to be parts of his team*”. This remark was helpful to the coach because SA revealed that the two foreign players of Maroussi were almost indispensable, while their coach alternated all the rest in the three remaining positions of histeam**.**

According to a different, “statistical” point of view, SA did not take into account the variant average playing time per game of Maroussi players and assumed that the analogies would be maintained in the game against IRAKLIS. Then, he noticed that:

1. “*The majority of 2p shots are attempted by the two foreign players of Maroussi, namely Turner (29.3%) and Amaya (26.6%). Moreover, the number of 2p attempts made by Papachronis (13.1%) and Panagiotarakos (10.4%) is significant*”. SA observed that the foreign players were attempting more than 50% of the total 2p shots of Maroussi, namely 55.9%. Obviously, IRAKLIS should be very careful on their guarding.
2. “*Korfas shoots the majority of the 3p shots of Maroussi, i.e. 32.5%.*
3. “*The most successful shooters of Maroussi in 2p shots arise if Karaplis (who succeeded in his two 2p attempts) and Korfas (with only two successful - out of three - 2p shots) are ignored. Five players shoot with a percentage of more than or around 50%*”.

SA informed the coach that four players, namely Amaya, Panagiotarakos, Papachronis and Turner, made 2p shots with at least a 50% accuracy percentage and tried more than 79.4% of the total 2p attempts of their team! Consequently, IRAKLIS’ defense on them and especially on their 2p shots should have been more effective!

1. “*The three Maroussi players that present a very good 3p shots percentage (namely Falekas, Pandeliadis and Karaplis) attempt only 18.2% of the total 3p shots. All the other players that shoot for 3p have a much worse accuracy percentage*”.

As the 3p shots would not have been a threat for IRAKLIS, SA suggested that it would have been preferable to “allow” this kind of shots, instead of 2p ones, in which Maroussi players proved to be far more efficient.

1. “*Examining two* *penetration indexes[[4]](#footnote-4), it comes out that mainly Panteliadis and Falekas, as well as Korfas and Karaplis, attempt a lot of drives during a game*”.

Once again, the coach had to exploit the SA remarks xi and xiv by himself.

Considering another interesting index, namely the percentage of 2p shots that a team attempts,

 (8)

and the real data of Maroussi (obtained from Table 3), it came out that the value of this index for Maroussi was equal to 74.2%. Considering this, SA noticed that “*Maroussi prefers to attempt mostly 2p instead of 3p shots*”.

The fourth part of the statistical analysis was usually about the performance and the statistical data of the players of IRAKLIS’ forthcoming opponent during the previous championship, either they played in the same team or in a different one. Obviously the number of players examined in this part of the analysis was restricted by the fact that many of the current (at the time) players of the team under study, especially the foreign ones, did not play for a Greek team the year before. Consequently no statistical data could be found and exploited for them. In any case, the information collected was very helpful to the coach. Based on a simple initial table (see Table 6 in our case) and an interesting statistical category, a particularly useful final table (such as Table 7) was created. Apart from each player’s percentage distribution regarding the various shooting spots, Table 7 presents the players’ 2p and 3p percentages during the previous championship.

### Table 6 about here

### Table 7 about here

Ignoring the highlighted players of Table 6 (due to the limited number of shots they have tried), the following conclusions arose, regarding the preferred shooting spots of Maroussi players:

* “*As far as 2p shots are concerned, almost all players of Maroussi prefer the centre, i.e. the area around the free throw lane*”.
* “*Only Turner does not seem to prefer a specific side of the court, either for 2p or 3p shots*”.

This unpredictable playing style made him extremely dangerous.

* “*Regarding 3p shots, Korfas, who is the most important shooter of Maroussi, obviously prefers the left side of the court.”*

SA mentioned that the fact that his 3p percentage was high made him an extremely dangerous offensive player.

* “*Manolopoulos and Panagiotarakos prefer to attempt 3p shots from the right side of the court, while Pandeliadis prefers the centre of the court*”.

Then, SA used the statistical data of Maroussi players reduced in an integrated time unit, i.e. the 40 min of a basketball game (Table 8), in an attempt to discover which of the players, while in court, could be a threat to IRAKLIS. Based on this analysis SA pointed out the following:

* *“Turner and Amaya win a lot of fouls during a game.*”.
* “*Apart from other statistical categories, the two foreign players are also Maroussi’s best when considering defensive rebounds. In this category, Karaplis and Zourbenko are also important players*”.
* “*As regards the offensive rebounds, only Amaya has notable contribution”*.

Consequently, SA mentioned that Amaya should be blocked out efficiently.

* “*Pandeliadis and Falekas are bound to make turnovers when under pressure. However, from all the players who basically take part in games (see Table 3), it is Turner and Panagiotarakos who make most of them*”.
* “*Despite their large number of turnovers, Pandeliadis and Falekas still maintain a strong presence in “stealing” a lot of balls from their opponents*.

### “*Korfas and Falekas stand out when it comes to assists*”.

* “*Finally, despite his limited playing time Zourbenko blocks a lot of his opponents’ shots*”.

Note that the highlighted players of Table 8 were not taken into account due to their limited playing time.

### Table 8 about here

# Assessment of the authentic statistical report through regression analysis

The statistical analysis presented previously could be (much) more advanced in several points, if the unfamiliar with statistics “recipients” were persuaded about their usefulness and the ability of quantitative methods and OR to improve the decision making process. For instance, an indicative direction of the statistical analysis addressed to the coaching staff of IRAKLIS could be the determination of factors that affect significantly or not, positively or negatively the performance of a team or a player, based on properly designed regression equations. According to the significance of those factors, the team’s coach could identify the statistical categories that they should concentrate on during a game.

To this end, using data in all statistical categories both for IRAKLIS and his opponents (such as those presented in Tables 1 and 2 respectively), considering, however, the total number of games of the 1999-2000 season (26 games), we arrive at the following multiple regression equation. In this model, the dependent variable Y expresses the difference between the total points scored and allowed by IRAKLIS at the final score of each one of the 26 games of the 1999-2000 championship:

 (9)

It should be noted here that in order to select the predictive variables of (9) we use the stepwise regression method, as well as one of the most common software for analyzing statistical data, i.e. MINITAB 16. The regression model in (9) explains 96.09% of the sum of squares and reveals the 11 statistical categories (among the 26 potential predictors/statistical categories) that contribute “significantly” to the prediction of the dependent variable Y, i.e. of the outcome of a basketball game of IRAKLIS, expressed by the difference between IRAKLIS’ and his opponent’s scoring.

Adding as a potential predictor the ordinal variable HE, which takes the value 1 for every home game of IRAKLIS and the value 2 for every away game, we arrive at a slightly different regression model:

 (10)

where 97.55% of the sum of squares is explained by the regression model. Considering this model as more appropriate, we could represent its residuals (predicted minus observed values) versus fits in order to determine the randomness of the residuals, i.e. if they consist background noise. Normally, the residuals should be distributed randomly across the diagram, while any obvious patterns could indicate model inadequacy. In Figure 3, we can not see any patterns apart from some extreme values; therefore, we can consider that the specific model is adequate for any further use.

### Figure 3 about here

Getting back to (9) and going one step further, we consider that in practice it usually turns out that a predictor whose estimated coefficient has a p-value p greater than α = 0.05 can be dropped from the model without affecting the error measures to a great extent. Consequently, examining the 11 p-values we can figure out that 3pAt, DREBt, OREBo and 1pAo, could be in turn omitted from the regression model; the fact that p ≥ 0.05 for all these variables, means that they may only be “accidentally” significant. The exclusion of each one of the four predictors leads to the same number of regression models which explain 95.1%, 94.9%, 94.8% and 94.8% of the sum of squares, respectively. Moreover, by dropping all four parameters at the same time, the regression model is simplified as follows:

 (11)

and explains 89.7% of the sum of squares.

Based on the last model, we find out that four statistical categories of IRAKLIS and three of his opponents play the most significant role in the outcome of a game, i.e. the 2p and 3p shots percentage and the turnovers of both IRAKLIS and his opponent, as well as the offensive rebounds of IRAKLIS. Using this finding and, generally, the analysis of this Section we can easily “assess” various parts of the authentic statistical report presented in Section 3. We can see that the significance of the 3p shots percentage of IRAKLIS had been pointed out by the SA with great emphasis (point iii). Moreover, SA had made indirect comments about the importance of IRAKLIS’ turnovers (point v), as well as 1p attempts (point iv) and rebounds (point v) whose significance was identified in model (9). On the contrary, he had not made relevant comments for the other statistical categories whose significance is proved by the regression model (9). However, this can be attributed to various reasons such as the fact that the authentic report had been based on only six games, while the derivation of (9) and (11) uses information from 26 games.

# Some additional ideas of statistical analysis

Having the necessary playing data, the suggested quantitative methods and statistical analysis addressed to the coaching staff of a team could be more sophisticated and helpful, in various other directions. In what follows we present some additional ones. First, the analysis could include *comparisons of statistical data* and, consequently, of *performance*, in several interesting statistical categories, between

* the team under study (TUS) - e.g. IRAKLIS - against another interesting team (e.g. the best in the championship) or the forthcoming opponent of TUS, in order to identify points of supremacy or weakness of the former.
* a TUS player against
  + another TUS player (in statistical categories that this comparison is meaningful),
  + the best in a statistical category (e.g. the best in assists ranking),
  + the respective player of the forthcoming opponent of TUS (e.g. comparison of the two play-makers),
  + a player of special interest (e.g. the predecessor of TUS player),
* any interesting TUS pentad[[5]](#footnote-5) against
  + another TUS pentad5,
  + the best pentad5 in a statistical category (e.g. offensive rebounds),
  + the pentad5 of the forthcoming opponent of TUS that has the larger playing time,
  + a pentad5 of special interest (e.g. the previous year’s pentad of TUS),

Note that the mean values used for the aforementioned comparisons could also be used for conducting *Hypotheses testing* for the majority of those cases, in order to find out significant (or not) differences among players, teams etc. Moreover, the above analysis could focus on a part of the statistical data and be differentiated according to various criteria (individually or in combination) like

* the home or away games,
* the period of game (e.g. using statistical data only for the 1st or 2nd etc. period, or for the 1st or 2nd half of the game),
* the result of the game, i.e. using statistical data of the wins or the losses,
* the round of the championship, i.e. using data of the first round (or the beginning of the season) or of the second round (or the end of the season),
* the domestic or European competitions,
* the strength of teams (adopting for example three strength levels, i.e. large, medium, small) etc.

Another interesting field of OR quantitative techniques could include the *formulation*, the *calculation* and the *exploitation for comparisons of complicated indexes*, and, mainly, *the monitoring* of their *values* in the course of time. For instance, Kubatko et al. (2007) present some very interesting indexes such as i) an estimation of possessions for team t, i.e. POSSt

 (12) [[6]](#footnote-6)

ii) the points scored (PTSt) and allowed (PTSo) per 100 possessions, which are called offensive rating (ORt) and defensive rating (DRt), respectively, for team t

 (13)

 (14)

and iii) the rebound rate or rebound percentage for player x, i.e. REB%x

. (15)

Furthermore, on [www.nba.com/statistics/efficiency.html](http://www.nba.com/statistics/efficiency.html) the efficiency statistic for player x, i.e., EFFx, is determined as

. (16)

This index allows NBA coaches to quickly evaluate a player's game performance. However, Berri (2008) has come out in opposition of traditional linear weights-style NBA evaluatory statistics like this one, claiming that they overvalue scoring and undervalue shooting efficiency.

The regression analysis which has been presented in Section 4 can deal with many more issues, such as the formulation of a “better” or a dynamically adaptive regression model, the determination of potential uses of the model etc. Despite the belief of many researchers, who claim that “wins are simply determined by points scored and surrendered per possession in basketball”, regression analysis can actually give fruitful insights regarding the decision making process in basketball. Obviously, a “passe-partout” regression model, which would be optimal for any basketball team, of any country and any period of time, can not be developed. Considering the dynamic nature of sports, any regression model should be determined per case and should be updated continuously in order to be useful for decision making purposes.

# What do coaches believe about all these?

Apparently it is difficult to make a general statement regarding this issue; familiarization and, consequently, response of coaches to statistical support and OR techniques are different in the U.S., Europe or other countries less favorable to basketball. Moreover, coaches’ tendency of using statistical information increases as time passes and so does maturity on this issue. Primarily coaches are happy just to get “numbers” printed on a piece of paper after the game. However, they quickly progress and begin to analyze the significance of the numbers and what they actually indicate. Lastly, coaches progress to a level of maturity where they use this data and information as a tool in planning and implementing practices and game preparation. As a result, their team's and individual players’ performances are greatly improved.

In the U.S., several NBA teams already employ statistical analysis, and presumably, the continued and growing employment of statistical analysts suggest that the teams find their work to be useful. However, a competitor of statistical analysis and, generally, quantitative methods is the modern techniques of basketball scouting, according to which coaches and mainly their assistants x-ray their team’s opponent based on video analysis.

# Conclusions

What we present in this paper is an indicative part of a real statistical analysis that the author conducted on a weekly basis, a few years ago, in order to support a Greek basketball team, namely IRAKLIS, and, more specifically, the decision making process of its coach at the time, Dragan Sakota. The analysis though statistically simple, seemed impressive to the coaching staff of IRAKLIS. The impression of SA was that this analysis could not be more complicated at that moment, because the exploitation of the statistical analysis procedure should be progressive so that everyone would have the necessary time to assimilate the whole process and understand the value of statistics and OR.

Undoubtedly, the future research can be more than wide as basketball statistics are at their infancy. In Sections 3 and 4 we refer to a few ideas. However, another interesting direction could be the on line, i.e. during the game, update of a team’s or player’s data and evaluation, using various statistical techniques - for example, the Bayes’ theorem - in order to optimize the crucial decisions a coach needs to take during a game.

# References

1. Albert, J., Bennett, J. & Cochran, J.J. (2005). *Anthology of Statistics in Sports*, SIAM.
2. Bean, J.C. & Birge, J.R. (1980). “Reducing Traveling Costs and Player Fatigue in the National Basketball Association”, *Interfaces*, 10 (3), 98-102.
3. Berri, D. J. (1999). “Who is ‘most valuable’? Measuring the player’s production of wins in the National Basketball Association”, *Managerial and Decision Economics*, 20, 411-427.
4. Berri, D.J. (2008). “A Simple Measure of Worker Productivity in the National Basketball Association”, In *The Business of Sport*; eds. Brad Humphreys and Dennis Howard, 3 volumes, Westport, Conn.: Praeger: 1-40.
5. Berri, D.J. & Schmidt, M.B. (2010). *Stumbling on Wins: Two Economists Explore the Pitfalls on the Road to Victory in Professional Sports*. Financial Times Press (Princeton, N.J.)
6. Berri, D.J., Schmidt, M.B. & Brook, S.L. (2006). *The Wages of Wins: Taking Measure of the Many Myths in Modern Sport*, Stanford University Press
7. Berri, D.J., Brook, S.L. & Schmidt, M.B. (2007). “Does One Simply Need to Score to Score?”, *International Journal of Sports Finance*, 2 (4), 190-205.
8. Brunswik, E. (1956). *Perception and the representative design of psychological experiments* (2nd ed.), University of California Press, Berkeley.
9. Calori, R., Steele, M. & Yoneyama, E. (1995). Management in Europe: learning from different perspectives, *European Management Journal*, 13, 1, 58-66.
10. Dubner, S.J. & Levitt, S.D. (2008). “Hoop Data Dreams”, *The New York Times*, May 4.
11. Dunwoody, P.T., Haarbauer, E., Mahan, R.P., Marino, C. & Tang, C.C. (2000). “Cognitive adaptation and its consequences: A test of cognitive continuum theory”, *Journal of Behavioral Decision Making*, 13, 1, 35-54.
12. Ghosh, A. & Steckel, J.H. (1993). “Roles in the NBA: there's always room for a big man, but his role has changed”, *Interfaces*, 23 (4), 43-55
13. Hammond, K. (1998). “Judgment and decision making in dynamic tasks”, *Information and Decision Technologies*, 14, 3-14.
14. Khatri, N. & Ng, H.A. (2000). The role of intuition in strategic decision making, *Human Relations*, 53 (1), 57-86.
15. Kubatko, J., Olivery, D., Pelton, K. & Rosenbaum, D.T. (2007). “A Starting Point for Analyzing Basketball Statistics”, *Journal of Quantitative Analysis in Sports*, 3 (3), 1-22.
16. Kvam, P. & Sokol, J.S. (2006). “A logistic regression/Markov chain model for NCAA basketball”, *Naval Research Logistics*, 53 (8), 788-803.
17. Morse, A.L., Shapiro, S.L., Mcevoy, C.D. & Rascher, D.A. (2008). “The effects of roster turnover on demand in the National Basketball Association”, *International Journal of Sport Finance*, 3 (1), 8-18.
18. Oliver, D. (2004). *Basketball on Paper: Rules and Tools for Performance Analysis*, Potomac Books Inc.
19. Popp, N., Pierce, D. & Hums, M.A. (2010). A comparison of the college selection process for international and domestic student-athletes at NCAA Division I universities, *Sport Management Review*, In Press - Available online 2 October 2010
20. Sampaio, J., Janeira, M., Ibáñez, S. & Lorenzo, A. (2006), “Discriminant analysis of game-related statistics between basketball guards, forwards and centers in three professional leagues”, *European Journal of Sport Science*, 6 (3), 173-178.
21. Schwertman, N.C., McCready, T.A., & Howard, L. (1991). “Probability models for the NCAA regional basketball tournaments”, *American Statistician*, 45, 35-38.
22. Winston, W.L. (2009). *Mathletics: How Gamblers, Managers, and Sports Enthusiasts Use Mathematics in Baseball, Basketball, and Football*. Princeton University Press
23. Zak, T.A., Huang, C.J., & Siegfried, J.J. (1979). “Production efficiency: The case of professional basketball”, *Journal of Business*, 52, 379-392.

**Table 1:** Basic statistical categories of IRAKLIS during the first six games of the Greek championship of 1999-2000

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Game vs** | **Home/Away game** | **Points** | **Free throws** | | | **2p shots** | | | **3p shots** | | | **Earned**  **fouls** | **Rebounds** | | | | **Turnovers** | **Assists** | **Steals** | **Blocks** |
| made | attempts | % | made | attempts | % | made | attempts | % | **Def.** | **Off.** | **Total** | **Opponent** |
| Aris | Home | **81** | 19 | 28 | 67.9 | 22 | 41 | 53.7 | 6 | 13 | **46.2** | 22 | 30 | 11 | 41 | 33 | 15 | 13 | 5 | 12 |
| Near East | Away | 56 | 6 | 10 | 60.0 | 19 | 43 | 44.2 | 4 | 19 | 21.1 | 17 | 20 | 13 | 33 | 43 | 15 | 11 | 11 | 3 |
| Peristeri | Home | **75** | 18 | 28 | 64.3 | 15 | 35 | 42.9 | 9 | 19 | **47.4** | 26 | 18 | 16 | 34 | 31 | 10 | 11 | 7 | 1 |
| AEK | Away | 60 | 7 | 10 | 70.0 | 22 | 45 | 48.9 | 3 | 13 | 23.1 | 17 | 20 | 9 | 29 | 35 | 11 | 14 | 4 | 4 |
| Panionios | Home | 63 | 15 | 19 | 78.9 | 15 | 33 | 45.5 | 6 | 20 | 30.0 | 19 | 28 | 8 | 36 | 35 | 12 | 7 | 3 | 1 |
| Dafni | Away | **81** | 14 | **19** | 73.7 | 20 | 35 | 57.1 | 9 | 20 | **45.0** | 23 | 29 | 8 | 37 | 28 | 16 | 14 | 11 | 1 |
| **Total** | | **416** | **79** | **114** | **69.3** | **113** | **232** | **48.7** | **37** | **104** | **35.6** | **124** | **145** | **65** | **210** | **205** | **79** | **70** | **41** | **22** |
| **Averages** | | **69.33** | **13.17** | **19** | **18.83** | **38.67** | **6.17** | **17.33** | **20.67** | **24.17** | **10.83** | **35** | **34.17** | **13.17** | **11.67** | **6.83** | **3.67** |

Note: the colours in the 1st column represent the result of the specific game according to the colours of the score sheet given to winning and losing team respectively: for example IRAKLIS has won the game versus Aris and has lost the game versus Near East etc.

**Table 2:** Basic statistics describing the performance of IRAKLIS’ opponents during the first six games of the Greek championship of 1999-2000

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Game vs** | **Power of opponent** | **Points** | **Free throws** | | | **2p shots** | | | **3p shots** | | | **Earned**  **fouls** | **Rebounds** | | | | **Turnovers** | **Assists** | **Steals** | **Blocks** |
| made | attempts | % | made | attempts | % | made | attempts | % | **Def.** | **Off.** | **Total** | **IRAKLIS** |
| Aris | Medium | 69 | 11 | 18 | 61.1 | 23 | 47 | 48.9 | 4 | 12 | 33.3 | 17 | 22 | 11 | 33 | 41 | 12 | 10 | 8 | 2 |
| Near East | Small | 67 | 17 | 28 | 60.7 | 22 | 38 | 57.9 | 2 | 14 | 14.3 | 21 | 28 | 15 | 43 | 33 | 19 | 11 | 3 | 3 |
| Peristeri | Medium | 72 | 24 | 38 | 63.2 | 18 | 33 | 54.5 | 4 | 11 | 36.4 | 25 | 20 | 11 | 31 | 34 | 11 | 10 | 6 | 3 |
| AEK | Large | 68 | 22 | 31 | 71.0 | 17 | 38 | 44.7 | 4 | 11 | 36.4 | 24 | 24 | 11 | 35 | 29 | 12 | 10 | 5 | 7 |
| Panionios | Medium | 67 | 10 | 15 | 66.7 | 21 | 49 | 42.9 | 5 | 12 | 41.7 | 18 | 25 | 10 | 35 | 36 | 9 | 15 | 7 | 1 |
| Dafni | Small | 59 | 10 | 14 | 71.4 | 20 | 43 | 46.5 | 3 | 16 | 18.8 | 19 | 19 | 9 | 28 | 37 | 17 | 10 | 5 | 3 |
| **Total** | | **402** | **94** | **144** | **65.3** | **121** | **248** | **48.8** | **22** | **76** | **28.9** | **124** | **138** | **67** | **205** | **210** | **80** | **66** | **34** | **19** |
| **Averages** | | **67** | **15.67** | **24** | **20.17** | **41.33** | **3.67** | **12.67** | **20.67** | **23** | **11.17** | **34.17** | **35.00** | **13.33** | **11.00** | **5.67** | **3.17** |

**Table 3:** Box score of the first six games of Maroussi in the Greek championship of 1999-2000

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Minutes of participation** | **Points** | **Free throws** | | **2p shots** | | **3p shots** | | **Earned**  **fouls** | **Rebounds** | | **Turnovers** | **Assists** | **Steals** | **Blocks** | |
| made | attempts | made | attempts | made | attempts | **Def.** | **Off.** | **For** | **Against** |
| Falekas | 40 | 12 | 4 | 4 | 1 | 2 | 2 | 3 | 2 | 0 | 0 | 4 | 4 | 3 | 0 | 1 |
| Pandeliadis | 77 | 23 | 8 | 13 | 3 | 15 | 3 | 5 | 8 | 4 | 2 | 9 | 3 | 4 | 0 | 1 |
| Manolopoulos | 70 | 16 | 2 | 2 | 1 | 3 | 4 | 12 | 3 | 1 | 1 | 2 | 2 | 0 | 0 | 0 |
| Karaplis | 51 | 17 | 4 | 5 | 2 | 2 | 3 | 6 | 3 | 8 | 1 | 2 | 1 | 2 | 0 | 0 |
| Zourbenko | 56 | 19 | 7 | 8 | 6 | 12 | 0 | 1 | 5 | 8 | 3 | 2 | 0 | 1 | 8 | 1 |
| Panagiotarakos | 128 | 38 | 3 | 4 | 13 | 23 | 3 | 12 | 4 | 10 | 2 | 10 | 5 | 5 | 1 | 2 |
| Korfas | 157 | 47 | 16 | 19 | 2 | 3 | 9 | 25 | 17 | 5 | 2 | 9 | 22 | 0 | 0 | 1 |
| Papachronis | 115 | 29 | 1 | 2 | 14 | 29 | 0 | 0 | 5 | 11 | 4 | 8 | 6 | 3 | 1 | 0 |
| Turner | 211 | 88 | 24 | 38 | 32 | 65 | 0 | 6 | 39 | 38 | 10 | 17 | 16 | 6 | 4 | 2 |
| Amaya | 214 | 102 | 22 | 37 | 37 | 59 | 2 | 6 | 36 | 35 | 30 | 15 | 8 | 4 | 3 | 1 |
| Charalampidis | 20 | 4 | 0 | 0 | 2 | 5 | 0 | 0 | 0 | 4 | 1 | 2 | 2 | 0 | 0 | 0 |
| Logothetis | 33 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 1 | 2 | 1 | 1 | 0 | 1 | 0 | 0 |
| Anagnostou | 28 | 9 | 3 | 6 | 3 | 3 | 0 | 1 | 3 | 3 | 1 | 3 | 1 | 3 | 0 | 1 |
|  | | | | | | | | | | 61 | 51 |  | | | | |
| TOTAL | 1200 | 405 | 95 | 140 | 116 | 222 | 26 | 77 | 126 | 135 | 63 | 84 | 70 | 32 | 17 | 10 |

1 Team rebounds

**Table 4:** Notation used in various formulas

|  |  |  |
| --- | --- | --- |
| **Part A - For player x** | ATGx | average playing time per game for player x |
| GMx | games played for player x |
| MINx | minutes played for player x and |
| 1pAx | player’s x free throw attempts |
| 2pAx | player’s x two-point attempts |
| 2pMx | two-point shots made for player x |
| 3pAx | player’s x three-point attempts |
| 3pMx | three-point shots made for player x |
| P2px | percentage of two-point shots that player x attempts |
| P3px | percentage of three-point shots that player x attempts |
| 2p%x | player’s x two-point percentage |
| 3p%x | player’s x three-point percentage |
| PI1x | player’s x 1st penetration index |
| PI2x | player’s x 2nd penetration index |
| REBx | rebounds for player x |

|  |  |  |
| --- | --- | --- |
| **Part B - For team t** | λ | the fraction of free throws that end possessions (often λ = 0.44, Kubatko et al., 2007) |
| α | a parameter, 0 ≤ α ≤ 1 (often α = 1, Kubatko et al., 2007) |
| MINt | minutes played for team t |
| 1pAt | free throw attempts for team t |
| 2pAt | two-point attempts for team t |
| 2pMt | two-point shots made for team t |
| 3pAt | three-point attempts for team t |
| 3pMt | three-point shots made for team t |
| REBt | rebounds for team t |
| OREBt | offensive rebounds for team t |
| REBo | rebounds for the opponents o of team t |
| DREBo | defensive rebounds for the opponents o of team t |
| TOt | turnovers for team t |
| PTSt | points scored for team t |
| PTSo | points scored for the opponents o of team t, i.e. points allowed for team t |

**Table 5:** Special statistical indexes for the players of Maroussi based on the data of the first six games in the Greek championship of 1999-2000

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **GMx** | **ATGx** | **2p%x** | **3p%x** | **P2px** | **P3px** | **1st penetration index - PI1x** | **2nd penetration index - PI2x** |
| Falekas | 3 | 13.3 | 0.9 % | 3.9 % | 50.0 % | 66.7 % | 0.8 | 0.6 |
| Pandeliadis | 6 | 12.8 | 6.8 % | 6.5 % | 20.0 % | 60.0 % | 0.4 | 0.6 |
| Manolopoulos | 6 | 11.7 | 1.4 % | 15.6 % | 33.3 % | 33.3 % | 6.0 | 0.9 |
| Karaplis | 6 | 8.5 | 0.9 % | 7.8 % | 100.0 % | 50.0 % | 1.2 | 0.6 |
| Zourbenko | 4 | 14.0 | 5.4 % | 1.3 % | 50.0 % | 0.0 % | 0.1 | 0.6 |
| Panagiotarakos | 6 | 21.3 | 10.4 % | 15.6 % | 56.5 % | 25.0 % | 3.0 | 0.9 |
| Korfas | 6 | 26.2 | 1.4 % | 32.5 % | 66.7 % | 36.0 % | 1.3 | 0.6 |
| Papachronis | 6 | 19.2 | 13.1 % | - | 48.3 % | - | 0.0 | 0.9 |
| Turner | 6 | 35.2 | 29.3 % | 7.8 % | 49.2 % | 0.0 % | 0.2 | 0.7 |
| Amaya | 6 | 35.7 | 26.6 % | 7.8 % | 62.7 % | 33.3 % | 0.2 | 0.6 |
| Charalampidis | 3 | 6.7 | 2.3 % | - | 40.0 % | - | - | 1.0 |
| Logothetis | 5 | 6.6 | 0.5 % | - | 0.0 % | - | 0.0 | 0.3 |
| Anagnostou | 2 | 14.0 | 1.4 % | 1.3 % | 100.0 % | 0.0 % | 0.2 | 0.4 |

Note: the yellow highlighted cells represent the group of the best players of every statistical index, the blue highlighted cells represent the next level group, while in grey highlight we see the players with limited playing time, whose analysis should be taken into consideration with caution

**Table 6:** Preferred shooting spots of Maroussi players, during the Greek championship of 1998-1999

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | **Left side** | **Centre** | **Right side** | **Total** |
| **2p shots** | Falekas | 2 | 2 | 3 | 7 |
| Pandeliadis | 1 | 20 | 1 | 22 |
| Manolopoulos | 1 | 3 | 1 | 5 |
| Panagiotarakos | 7 | 11 | 3 | 21 |
| Korfas | 6 | 21 | 6 | 33 |
| Papachronis | 8 | 52 | 14 | 74 |
| Charalampidis | 2 | 3 | 3 | 8 |
| Logothetis | 1 | 2 | 1 | 4 |
| Turner | 39 | 38 | 38 | 115 |
| **3p shots** | Falekas | 0 | 1 | 3 | 4 |
| Pandeliadis | 17 | 20 | 6 | 43 |
| Manolopoulos | 12 | 5 | 17 | 34 |
| Panagiotarakos | 13 | 5 | 30 | 48 |
| Korfas | 52 | 39 | 24 | 115 |
| Logothetis | 1 | 2 | 2 | 5 |
| Turner | 19 | 13 | 17 | 49 |

**Table 7:** Percentage distribution of the preferred shooting spots of Maroussi players, as well as their 2p and 3p percentages, during the Greek championship of 1998-1999

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | **Left side** | **Centre** | **Right side** |
| **2p shots** | Pandeliadis | 4.5% | 90.9% | 4.5% |
| 2p % | 100.0% | 15.0% | 0.0% |
| Panagiotarakos | 33.3% | 52.4% | 14.3% |
| 2p % | 28.6% | 18.2% | 0.0% |
| Korfas | 18.2% | 63.6% | 18.2% |
| 2p % | 33.3% | 38.1% | 16.7% |
| Papachronis | 10.8% | 70.3% | 18.9% |
| 2p % | 62.5% | 28.8% | 57.1% |
| Turner | 33.9% | 33.0% | 33.0% |
| 2p % | 33.3% | 31.6% | 44.7% |
| **3p shots** | Pandeliadis | 39.5% | 46.5% | 14.0% |
| 3p % | 47.1% | 30.0% | 50.0% |
| Manolopoulos | 35.3% | 14.7% | 50.0% |
| 3p % | 25.0% | 0.0% | 41.2% |
| Panagiotarakos | 27.1% | 10.4% | 62.5% |
| 3p % | 0.0% | 60.0% | 16.7% |
| Korfas | 45.2% | 33.9% | 20.9% |
| 3p % | 46.2% | 38.5% | 50.0% |
| Turner | 38.8% | 26.5% | 34.7% |
| 3p % | 31.6% | 15.4% | 17.6% |

Note: every yellow highlighted cell represents the most preferable shooting spots for each player (if there is one), while every blue highlighted cell represents the next most preferable shooting spots

**Table 8:** Statistical data of Maroussi players reduced in 40 min, based on the box score of the first six games of Maroussi in the Greek championship of 1999-2000, i.e. Table 3

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Points** | **Free throws** | | **2p shots** | | **3p shots** | | **Fouls won** | **Rebounds** | | **Turnovers** | **Assists** | **Steals** | **Blocks** | |
| made | attempts | made | attempts | made | attempts | **Def.** | **Off.** | **For** | **Against** |
| Falekas | 12.0 | 4.0 | 4.0 | 1.0 | 2.0 | 2.0 | 3.0 | 2.0 | 0.0 | 0.0 | 4.0 | 4.0 | 3.0 | 0.0 | 1.0 |
| Pandeliadis | 11.9 | 4.2 | 6.8 | 1.6 | 7.8 | 1.6 | 2.6 | 4.2 | 2.1 | 1.0 | 4.7 | 1.6 | 2.1 | 0.0 | 0.5 |
| Manolopoulos | 9.1 | 1.1 | 1.1 | 0.6 | 1.7 | 2.3 | 6.9 | 1.7 | 0.6 | 0.6 | 1.1 | 1.1 | 0.0 | 0.0 | 0.0 |
| Karaplis | 13.3 | 3.1 | 3.9 | 1.6 | 1.6 | 2.4 | 4.7 | 2.4 | 6.3 | 0.8 | 1.6 | 0.8 | 1.6 | 0.0 | 0.0 |
| Zourbenko | 13.6 | 5.0 | 5.7 | 4.3 | 8.6 | 0.0 | 0.7 | 3.6 | 5.7 | 2.1 | 1.4 | 0.0 | 0.7 | 5.7 | 0.7 |
| Panagiotarakos | 11.9 | 0.9 | 1.3 | 4.1 | 7.2 | 0.9 | 3.8 | 1.3 | 3.1 | 0.6 | 3.1 | 1.6 | 1.6 | 0.3 | 0.6 |
| Korfas | 12.0 | 4.1 | 4.8 | 0.5 | 0.8 | 2.3 | 6.4 | 4.3 | 1.3 | 0.5 | 2.3 | 5.6 | 0.0 | 0.0 | 0.3 |
| Papachronis | 10.1 | 0.3 | 0.7 | 4.9 | 10.1 | 0.0 | 0.0 | 1.7 | 3.8 | 1.4 | 2.8 | 2.1 | 1.0 | 0.3 | 0.0 |
| Turner | 16.7 | 4.5 | 7.2 | 6.1 | 12.3 | 0.0 | 1.1 | 7.4 | 7.2 | 1.9 | 3.2 | 3.0 | 1.1 | 0.8 | 0.4 |
| Amaya | 19.1 | 4.1 | 6.9 | 6.9 | 11.0 | 0.4 | 1.1 | 6.7 | 6.5 | 5.6 | 2.8 | 1.5 | 0.7 | 0.6 | 0.2 |
| Charalampidis | 8.0 | 0.0 | 0.0 | 4.0 | 10.0 | 0.0 | 0.0 | 0.0 | 8.0 | 2.0 | 4.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| Logothetis | 1.2 | 1.2 | 2.4 | 0.0 | 1.2 | 0.0 | 0.0 | 1.2 | 2.4 | 1.2 | 1.2 | 0.0 | 1.2 | 0.0 | 0.0 |
| Anagnostou | 12.9 | 4.3 | 8.6 | 4.3 | 4.3 | 0.0 | 1.4 | 4.3 | 4.3 | 1.4 | 4.3 | 1.4 | 4.3 | 0.0 | 1.4 |

**Figure 1:** Rebounds, turnovers and assists of IRAKLIS during the first six games of the championship



**Figure 2:** Defense, rebounds and assists of IRAKLIS’ opponents during the first six games of the championship



**Figure 3:** Residuals versus fitted values of the regression model (10)



1. [www.nba.com/celtics/contact/front-office.html](http://www.nba.com/celtics/contact/front-office.html) [↑](#footnote-ref-1)
2. In our paper we refer to a specific game of the season 1999 – 2000, in which IRAKLIS outperformed Maroussi 92 – 75. Nowadays, Maroussi ([www.maroussibc.gr](http://www.maroussibc.gr)) is one of the greatest Greek basketball teams, participating in the Euroleague of 2009-2010, while in 2001 won its first European trophy (European Saporta Cup). [↑](#footnote-ref-2)
3. A basketball game in Europe lasts for 40 min [↑](#footnote-ref-3)
4. SA determined those indexes especially for this statistical analysis [↑](#footnote-ref-4)
5. or twosome/threesome [↑](#footnote-ref-5)
6. Strong disagreement has been expressed regarding this formula of Kubatko et al (2007), which is an estimated measure of possessions arising through regression that is probably mis-specified. Considering the way they define a possession, an offensive rebound does not start a new possession, but a new play. However, in this equation possessions are defined in terms of missed shots, i.e. 2pAt and 3pAt, missed free throws, i.e. 1pAt, and consequently in terms of offensive rebounds. [↑](#footnote-ref-6)