Research Article

Chinese Professional Basketball League Using Mobile Computing and Big Data Technology

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The impact of big data technology on the Chinese Men’s Professional Basketball League (CBA) is studied in this study. With the growth of the CBA league in recent years, teams from the western region have emerged. Although there is a trend of “multipolarization” in the competition pattern, it overall depicts a situation in which the east is strong and the west is weak. In addition, the method of recruiting foreign aid workers has improved over time, as has the foreign aid system. The number of foreign aids has increased from one in 1995 to a high of 47, and the quality of foreign aid has improved over time. This not only strengthens the club team, but it also has a significant impact on the CBA league’s competition patterns. The basic factors that affect the changes in the competition pattern are institutional factors, coaching factors, star player factors, foreign aid factors, regional economic factors, reserve talent factors, team style factors, player security factors, and so on, according to research and analysis of the CBA league’s development and changes. Six teams have won the CBA league championship in its 22 seasons. The Bayi and Guangdong teams each won eight times, accounting for more than 70% of the total number of championships.

1. Introduction

Many countries in the world today operate their own basketball leagues. One of the most concerned and attractive is the American Men’s Professional Basketball League, referred to as NBA. It is the highest level and largest basketball league in the world. Similarly, as the largest European basketball league in Europe, it is also developing and rising rapidly and is deeply loved by fans. With the footsteps of the world basketball competition, basketball has also spread rapidly in China and has a broad mass base. As the highest level of basketball league in China, CBA League represents the highest level of Chinese basketball and is widely concerned by fans. This paper summarizes and integrates the development and changes of the CBA league and the development of the competition pattern from the data, analyzes and reviews, and finds out the factors that affect the development of the competition pattern of the CBA league. It analyzes its influencing factors, in order to have certain reference and reference significance for the professional development of basketball in China. It provides some suggestions for the healthy development of the CBA league in the future. This research fully reflects the immeasurable role of big data technology in the reform of CBA.

The innovation of this paper are as follows:

(1) It gives a detailed description of several core big data technologies and repeatedly mentions the impact of big data on the current CBA

(2) It summarizes the development of CBA big data and gives the current problems of CBA big data, which provides a reference direction for the following research

(3) In this paper, the background difference method is used to detect the shot. This gives full play to the role of the algorithm in CBA shooting and also provides technical support for CBA image detection technology
2. Related Work

Regarding the research on big data technology and professional leagues, many scholars at home and abroad have provided a lot of references.

Dobbin et al. examine the standard and construct validity of isometric mid-thigh dynamometers to assess full-body strength in professional football league players. They found that isometric mid-thigh pulls assessed using a dynamometer underestimated standard peak strength but were able to distinguish between different professional standard professional rugby league players’ muscular functional characteristics [1]. Jung et al. examined the uncertainty of the outcome hypothesis for single-game and playoff appearances in the Korean Professional Baseball League from 2007 to 2015. Panel data analysis showed that the difference in winning percentages between the two teams and the uncertainty of the playoffs based on games behind are significant factors in the impact. This research has implications for policymakers and league owners to improve the self-sustainability of sports teams [2].

The goal of Yu et al.’s research was to see how competition location affected the set results and technical performance indicators of the Chinese Women’s Volleyball League. They watched a total of 656 games over the course of two seasons (2016-2018) (181 games). They looked at each team’s scores and turnovers in both home and away games [3]. Tang and Huo used wireless network planning to improve the synchronization of tennis professional league live broadcasts. The results of the experiments show that the synchronization optimization method has good synchronization, high resolution, short response time, and good detection effect [4]. The impact of online advertising in promoting the Nigerian Professional Football League was investigated by Anorue et al. (NPFL). They distributed 400 questionnaires to respondents in four states in north-central Nigeria using a survey research method. In comparison to other league organizers and club teams in developed countries, the study found that league management companies (LMCs) and NPFL club teams use online advertising less effectively. As a result, they recommend that league managers start thinking about putting together a well-equipped social media marketing team right away [5]. During the eight-week offseason, Dobbin et al. discovered mechanical changes in sprint performance in professional football league players. For professional football league players, the 8-week off-season resulted in negative changes in linear sprint time and horizontal force-velocity curves [6].

The data from these studies are not comprehensive, and the results of the studies are open to question. Therefore, it cannot be recognized by the public and thus cannot be popularized and applied.

3. Big Data Technology and CBA

3.1. Big Data Technology. Different industries or social roles have different interpretations and understandings of big data [7, 8].

Big data is one of the most popular financing labels among entrepreneurs and investors, and its capital catalytic effect far outnumbers previous O2O or P2P [9]. Many Internet companies that promote big data are traffic-driven from a global perspective. Its primary business is data collection and storage; data mining is insufficient, and the application is limited. They have a big data prototype and concept, but not the core of a big data company [10, 11].

Simultaneously, most big data businesses are restricted to using multiverse data for HDFS computing. Spark is currently the most popular computing tool, and it is a welcome addition for big data companies, engineers, and users. Multithread cooperation effectively connects heterogeneous data and systems while also creating a large number of job openings [12].

Big data application is a double-edged sword for consumers or most Internet users [13]. On the one hand, big data has greatly improved Internet users’ experiences, and it is also more sensitive to users’ consumption habits. Many intelligent suggestions are still in the early stages of development. Users’ personal information, on the other hand, is constantly leaked. It is always difficult to avoid user privacy leakage, despite the rapid introduction and implementation of relevant laws and regulations. If a user registers and logs in to an APP using a mobile phone, all actions performed on the phone may be linked to the user’s true identity. Android, in particular, allows APP developers to not only monitor the ownership APP in real time but also to access and share data with other APPs [14, 15].

Big data technology is not a completely new concept for most experts and academics. When data is stored to a certain extent and traditional methods are no longer effective [16], it is an unavoidable result of technological progress. AI and machine learning are frequently associated with big data. Big data and machine learning [17–19] are both components of AI, and machine learning necessitates a large amount of data. Machine learning, on the other hand, can generate a large amount of data that needs to be stored.

Big data technologies abound, and a slew of new ones emerge each year. Data acquisition and processing, data calculation mode and system, and data analysis and visualization are all examples of this.

3.1.1. Data Collection and Processing. In the big data system, data is crucial. In addition to reserve data, data acquisition and preprocessing are particularly important [20, 21]. At this stage, data collection mainly comes from the following four aspects:

(1) First, the Management Information System. Management information system is a system that processes human-led information in series with the help of computers, network communications, and other office equipment. It includes many aspects such as collection, delivery, storage, processing, maintenance, and use. Management information systems exist widely in all walks of life and at all levels of society, such as personal bills, supermarket commodity management systems, corporate personnel management systems, and public security management systems which are all management information systems that exist and rely on information data. These systems not only store massive...
amounts of data but also generate massive amounts of data all the time [22].

(2) Second, Web Information System. The Web information system relies on the Internet to provide services and is a network information service system for publishing, browsing, and querying information [23, 24]. In the Web information system, its data includes many aspects. Generally speaking, the data is the database information rendered by the front end. Most of this part of the data is real-time data, and there are also massive historical data and related metadata in the database. At the same time, page visit records are also considered as data in Web information systems. This data is particularly important for intelligent recommendation, user habit research, and application, such as Dianping, Fangtianxia, and other websites.

(3) Third, Physical Information Systems. Physical information systems include many systems engineering, such as environmental perception, embedded computing, network communication, and network control. These projects are generating massive amounts of relevant data every moment in the process of using and collaborating. For example, the development of intelligent transportation system and vehicle navigation technology can sense the situation of population travel and migration in real time. In addition, the mobile phone was once considered a physical information system, because its core function was mainly communication, not APP computing.

(4) Fourth, the Scientific Experiment System. Strictly speaking, a scientific experiment is not a complete system. But it is undeniable that scientific experiments generate massive amounts of data. The vast majority of these data are used for scientific research, promoting the progress of human society and technological innovation. And every major scientific experimental research needs a lot of data as support. The data mentioned here includes both data used for scientific research and data generated by scientific research.

3.1.2. Data Calculation Mode and System. The computing mode of big data usually refers to the different characteristics of the data itself and its different computing and analysis requirements. It combines the actual needs and application directions to build a variety of different abstract models. Compared with the traditional lower-level parallel computing methods, such as the parallel abstract computing model established from a simple architecture or programming language, big data has higher-level requirements whether it is at the level of data characteristics or at the level of computing characteristics. Traditional parallel computing methods can no longer fully meet its development needs and have to try to build higher-level computing models, such as the distributed memory abstract RDD established by the famous University of California, Berkeley.

Various demands have emerged from big data application research. Big data, on the other hand, has a variety of characteristics. As a result of this situation, a number of common or important big data computing models have emerged, and application tools are gradually appearing on the market or in scientific research. Many science and technology companies that focus on big data are currently developing and improving a set of new data processing and analysis tools. To meet the needs of explosive data growth, it may embed the functions of traditional tools into a distributed computing model. Of course, different tools are required to match different requirements and abstract computing models, which is also one of the trends in the commercialization of big data.

3.1.3. Data Analysis and Visualization. The visualization of big data and its icon system is one of the cores in the early stage of big data application research, and it is particularly important at this stage. Visualization and icon system are the basis of big data application research, and data mining and interactive exploration are built on it, which is an unavoidable problem both at home and abroad. At the beginning of 2017, many big data application platforms, including Tencent Location Big Data, SuperMap, Maphui, and Jihai, interacted with users more at the level of visualization. This not only shows the importance of visualization for big data but also reflects the dependence of big data analysis and mining on visualization.

Parallel and distributed computing are the most mainstream and core computing methods and abstract models of big data at this stage. It is used not only for data processing, data analysis but also for visualization.

3.1.4. Big Data Platform Architecture. The characteristics of big data make it more demanding on computer platforms. It must not only meet the processing needs of massive and multisource data but must also improve its running rate, which is undoubtedly very demanding for common platform architectures. In order to meet the needs of big data analysis and processing, new IT technologies are constantly being developed and used. At present, in terms of platform architecture, Hadoop and Spark have great advantages and are widely used. With the deepening of the concept and application of Hadoop, distributed computing platforms are generally called Hadoop. Spark is simply a data processing engine. It integrates many data engines suitable for big data analysis applications, including machine learning libraries, and is also a new IT technology with the development of big data technology. The architecture diagram of Hadoop is shown in Figure 1.

Hadoop and Spark have the inherent relationship of complementing each other and exploiting their strengths and circumventing their weaknesses. Both are currently the most widely used open-source frameworks. In many cases, Hadoop and Spark are used to build big data platforms at the same time. The most common combination method provides Hadoop with a highly scalable and malleable platform basic architecture, while opening interfaces for Spark servers and providing a powerful data engine. But Hadoop and Spark also have their own advantages and disadvantages.

First of all, Hadoop is the most typical implementation of a distributed file system, and it has strong scalability, especially in terms of horizontal expansion. And the server
requirements are low, and ordinary servers can meet most of its needs. At the same time, Hadoop’s operational costs are relatively low. Relatively speaking, Spark has higher requirements on the server. It mainly provides data engine technology, which is usually not used for distributed data storage.

Second, the two methods of disaster recovery are very different. This mainly depends on how the two store the intermediate data generated during processing. Under normal circumstances, Hadoop will record the data processed each time in the disk, which ensures that it has a more flexible recovery method and mediation space in the event of a disaster. For Spark, data-related objects are stored in Resilient Distributed Datasets (RDDs), which means that data objects can be stored in server memory or written to disk. It also has disaster recovery capabilities. The former has a higher risk, especially when processing multiple concurrent requests, and each request involves a large amount of data, which may lead to server memory overflow. In the absence of external interference, all requests are recorded in the file and cannot be completed successfully.

Furthermore, there is a big difference between the two in terms of usage scenarios. Among them, Hadoop is more suitable for offline scenarios. Based on its strong data requirements, Spark is more suitable for computationally complex or more iterative computing scenarios.

Finally, from the perspective of stability, the interaction in Hadoop is carried out in the disk, which has stronger stability. Spark pursues high flexibility and is more used in complex or more iterative computing scenarios, which leads to its relatively poor stability.

3.2. CBA. The CBA is sponsored and supervised by the Chinese Basketball Association (hereinafter referred to as the Basketball Association). From the competition rules, penalties, team information, etc. are managed by the Basketball Association. The statistics of each game and each season are also kept by the Basketball Association.

3.2.1. Budding Period. The technical representatives on the sidelines were primarily responsible for the first ten years of the CBA league’s development. They use paper forms to record game scores, player technical statistics, and other data, which they then submit to the Basketball Association’s relevant departments after the game. There are a few items in the game data statistics, as well as referee misjudgments and manual information recording errors. Official statistics serve as the only reference standard because each club lacks the necessary data collection tools and data analysis teams. The video of the game is only recorded by the club’s equipment, and it has not been subjected to any analysis or processing, nor has any valuable data information been unearthed. Each team does not currently have the conditions for official broadcast recording of player performance in the game due to the privacy of the team’s internal intelligence. As a result, the game video data collected is uneven in terms of recognition degree, analysis, and utilization value, and each team has made a relatively small investment in this area.

3.2.2. Slow Development Period. In 2005, CBA entered a period of slow development of data collection and analysis technology. Guangdong Hongyuan Club (now renamed Guangdong Dongguan Bank Club) took the lead in introducing foreign advanced video analysis technology. This marks the beginning of high-tech integration into Chinese professional sports events. After 2008, the CBA gradually learned from the successful experience of the NBA in the application of data collection and analysis technology. However, in the early days, the collection and analysis of data information still remained on the collection of game video.

Teams and clubs send special personnel to the scene to record every game of the team through a camcorder, and then, they burn the video data to discs. Through the video player, it is available for analysis and discussion at the regular meeting of the team’s coaching staff. This method is usually used in the formulation of one’s own tactics and the analysis of the opponent’s technical and tactical characteristics.

However, at that time, the CBA official did not have a unified video database and did not provide video playback services for related games. And these video materials are relatively confidential to a certain extent and are regarded as internal video materials by each team and are not disclosed and shared. Although the CBA cooperates with the media to carry out live TV business, the live or broadcast events are only part of the entire schedule, not every game. In order to better study the confrontation situation and formulate relevant techniques and tactics, the coaching staff of each club must have the club staff record the whole game separately for timely use. With the development of science and technology, portable video collection equipment emerges in an endless stream, and the information collection personnel of CBA clubs are also gradually equipped with these high-tech tools.
3.2.3. Rapid Development Period. China, as a large information country and Internet user, has shown tremendous development potential since the dawn of the Internet era. Internet "giants" have seized the Internet market and ventured into a variety of fields. The secondary professional basketball team has successfully reached cooperation agreements with a number of Internet companies as a major "position" in the field of professional sports. Currently, a number of Internet companies, such as Sohu Sports, have joined the collaboration and are gradually building a database for the Chinese Basketball Association’s official website. It keeps track of the league’s game data, videos, and other materials and makes them available to the public. This provides a solid foundation for determining a player’s competitive status and developing team strategies. Webcasting technology is maturing as Internet information transmission technology becomes more popular. Commercial cooperation for CBA event broadcasting rights has also improved over time, and more video data from CBA events is shared in real time via network signals. It is also saved by the network server, which not only allows media and fans to watch the game but also gives each team and club a shortcut to collect video data from the game. Some unofficial individuals or organizations reprocess the video data of players or teams by promoting online self-media. It analyzes and summarizes various event data from various perspectives before resharing it on the Internet as video highlights and event comments. This provides materials for the collection and analysis of game data to the general public invisibly.

At present, in addition to the various CBA authoritative data released by the official website of the Chinese Basketball Association, Sina Sports, Tencent Sports, Hupu Sports, and other domestic large-scale sports event, portal websites all provide live events and the collection and sharing of game data. It also includes popular commentary and media analysis, among others (Table 1).

Through the above analysis, it is found that the data collection and analysis technology of domestic basketball events has evolved from simple induction to complex calculation. New technologies, new equipment, and new concepts have become the key elements of data processing in basketball events and have played a positive role in promoting the development of the league. The use of data collection and analysis technology in professional basketball events in China has just started, and there is huge room for development.

As the game progresses, the team members responsible for observing the game make real-time oral broadcasts of the situation on the field, which has high requirements for the accuracy and standardization of the broadcast. The members responsible for data recording will accurately record the information in the statistics table and input it into the database through the computer according to the broadcast information heard. After the game, the staff should check the accuracy of the data and make a paper form of the technical statistics of the game.

The CBA official is equipped with the software for managing the game database—the basketball game live technical statistics system. Through the system, it can find detailed game statistics at any time, including points, rebounds, assists, and hit rate. These data can also be exported to make technical statistics paper reports as needed. In addition, the statistics system is also associated with the subtitle display, which realizes the synchronization of the game and the data recording. The recorded data can be transmitted to the database of the official website of CBA through the network, and the operation is convenient and fast, saving a lot of cost of information statistics.

Up to now, CBA big data is still in the preliminary application stage. The big data currently used in the CBA league is very limited, which is mainly reflected in the following four aspects:

1. During the game, the event commentators and the media can use the on-site statistics of the technical statistics team to provide data commentary for the game and improve the fans' viewing experience. However, the CBA league currently only explains simple data such as shots, rebounds, and turnovers, which is far from satisfactory to the audience.

2. It uploads the statistical game data to the CBA official website, and basketball fans and researchers can obtain these data through the official website, which has played a certain role in promoting the league. Researchers can analyze the game-related data, find problems, write and publish papers, and provide suggestions for promoting the development of the CBA league.

3. The statistics of players and team technical indicators provide an objective basis for the evaluation of the best division, the most valuable player, and the best newcomer, and individual awards and provide a reference for the introduction or renewal of players of each team.

4. Domestic coaches can use video analysis software to analyze the video of the game by means of video analysis and analyze the main members, key tactics, and characteristics of the opponent team. They also analyze their own team’s shortcomings and develop training plans and game strategies with the help of data analysis.

The accumulation of CBA big data started in 1995. After more than 20 years of development, it has initially taken shape, mainly including game data.

CBA collects and processes data through on-site technical statistics and video, uses video analysis software to analyze and research the original game data, and further excavates the data through coaches and video analysts. This, in turn, applies these data to training and competitions, so as to guide training and competitions in a targeted manner, and improve players’ technical and tactical levels and team competition results. It is the application of big data in the CBA league that continuously promotes the development of the CBA and improves the overall level of the CBA.
The coaches of each team are the direct beneficiaries of big data mining applications. Data mining can discover certain rules or associations in massive databases that cannot be easily discovered. This hidden information provides a reference for the coach, which can help the coach to better formulate training plans and game tactics. Refined statistics have become the coach's secret weapon. Whoever can master the more data of the opponent will have the initiative in the game. In the past, coaches used experience and intuition to guide training and formulate game tactics. Now, coaches can thoroughly quantify the situation on the training field and the game field through big data mining. In the past, the coach only knew that there were two players in the team who handled the key ball very well. But mining the data can tell the coach much more detail, such as how often the two players have been successful on key balls in the past. The analysis and mining of big data make the training plan formulated by the coach more reasonable and the game tactics more accurate. The days of experience and intuition alone are over, and applying big data to training and competition can make a qualitative leap in coaching.

The data in the CBA database, whether individual or team data, is about the athletes themselves, and the athletes are closely related to these data. The analysis and mining of big data can make the indicators of athletes more detailed. Some of these indicators are usually not easy to find. According to the results of big data analysis, each player can understand his own strengths and weaknesses. In the process of training and competition, they can constantly make up for their own deficiencies, develop their own advantages, constantly improve their game scores, and play their potential. At present, the training of CBA teams is the same, with little success. The application of big data can allow athletes to train in a targeted manner, so as to better improve their sports level.

Fans and spectators are crucial to the development of the CBA league. When watching the game, letting the audience know more professional data and the content behind the game can improve the watching experience of fans and spectators. During the broadcast of the game, by deeply analyzing and mining the game data and previous game data and applying these data to the broadcast process, unexpected results can be obtained. At present, the broadcast of CBA games only explains some primary data, such as rebounds, fouls, and assists. The audience is always complaining that the commentary is not good enough and that there is nothing new. If some excavated data can be added to the commentary, the audience will definitely applaud. Quantitative information explanation can let the audience know more information and enhance the fun of watching the game.

The application of big data can bring the audience a new experience of watching the game, and at the same time, it is of great benefit to increase the attention of the CBA league.

The application of big data has raised the player’s physical fitness level, the team’s technical and tactical level, and the attention of the game to a new level. Players have improved their physical fitness level through targeted training, and the team’s technical and tactical strategies are more reasonable based on their own and opponents’ characteristics. These will make the CBA game more exciting, and more basketball fans will pay attention to the CBA league in the future. The application of big data has brought China's CBA league into a new stage of development, effectively shortening the gap between China and the world basketball league and improving the international status of the CBA league.

The implementation of big data technology is based on a huge and accurate database. Therefore, in order to realize data analysis and mining in the CBA league, it is necessary to establish a database system with complete data to count the detailed information of teams and players from all aspects, as shown in Figures 2–5.

The above is just a model of the basic information about the database. In order to further refine the game data, further detailed data needs to be added. For example, for a player's shot, as shown in Figure 6.

There are many similar data as detailed as possible. Only when the detailed data collection work is done well can the development of data mining be guaranteed. In other words, huge and accurate database data is the premise and foundation of all data mining and is the most important and critical link. Correlations between data are equally important.

### 4. Shot Detection Algorithm

The basic idea of the background difference method is to match the current frame image with the known background model reference image. It calculates the similarity measure between each point of the image and the point in the background model and can perform foreground/background classification by the following formula:

$$
\rho_I(\mu, \nu) = \begin{cases} 
1 & |\rho_d(\mu, \nu) - \rho_e(\mu, \nu)| \geq \alpha, \\
0 & |\rho_d(\mu, \nu) - \rho_e(\mu, \nu)| < \alpha.
\end{cases}
$$

In the above formula, point \((\mu, \nu)\) is any pixel in the image, \(\alpha = 0, 1, 2, \cdots, i - 1\) and \(\beta = 0, 1, 2, \cdots, j - 1\), where \(i\) and \(j\) represent the vertical and horizontal resolutions of the image, and \(d\) and \(e\) represent the vertical and horizontal resolutions of the
image, respectively. $\rho_k(\mu, \nu)$ is the eigenvalue of pixel (\(\mu, \nu\)) in the background reference model, $\rho_d(\mu, \nu)$ is the eigenvalue of pixel (\(\mu, \nu\)) of the currently captured image frame, and \(\alpha\) is an artificially set or adaptive segmentation threshold.

The background reference model is as follows:

$$X_t = \frac{1}{T} (\delta_t + \delta_{t-1} + \cdots + \delta_{t-T+1}),$$

where \(T\) is the number of frames to be averaged.

The way to update the background model is

$$X_t = X_{t-1} + \frac{1}{T} (\delta_t - \delta_{t-T}).$$

It uses the kernel function to estimate the probability density distribution of the pixel value \(\mu_a\) of the current pixel at time \(a\):

$$p(\mu_a) = \frac{1}{T} \sum_{k=1}^{T} M_g(\mu_a - \mu_k),$$

$$M_g = \left(\frac{1}{g}\right) M\left(\frac{a}{g}\right),$$

where \(M_g\) represents the kernel function and \(g\) is the width of the kernel function.

If the Gaussian kernel function is selected and it is assumed that the various features of the pixels are independent of each other, then there are

$$p(\mu_a) = \frac{1}{T} \prod_{k=1}^{T} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2}\left[\frac{(\mu_a - \mu_k)^2}{\sigma^2}\right]},$$

where \(n\) is the median of the absolute difference between the pixel feature values of two adjacent image frames.

$$n = \text{median}(|\mu_k - \mu_{k+1}|).$$

It finds a threshold that maximizes the sum of the entropy of the two types of information, the foreground point and the background:

$$q_k = \frac{T_k}{T * \text{median}},$$

where \(T_k\) represents the entropy of the target area, \(O\) represents the gray level in the image, and \(F_c\) represents the entropy of the background area.

$$F_\delta = -\sum_{k=1}^{A} \frac{Q_k}{Q_a} \log \frac{Q_k}{Q_a},$$

$$F_c = -\sum_{k=A+1}^{O} \frac{Q_k}{1-Q_a} \log \frac{Q_k}{1-Q_a}.$$

It uses the maximum entropy method to find the best threshold method in the image:

$$A = \text{argmax}[F_\delta(A) + F_c(A)].$$

The average grayscale method is as follows:

$$A = \sum_{j=0}^{j=D} \frac{\delta(k, h)}{T}.$$

Among them, \(O\) represents the maximum gray level of the image, \(\delta(k, h)\) represents the gray value of a certain pixel in the image, and \(T\) represents the total number of pixels in the image.

First, it assumes that the range of gray values in the entire image is in [0, 0-1]. In the grayscale image, the number of pixels with the grayscale value of \(k\) is \(t_k\); then, \(T\) can be expressed as

$$T = \sum_{k=0}^{O-1} t_k.$$
The probability of occurrence of each gray value is
\[ q_k = \frac{t_k}{T}. \]  \hspace{1cm} (16)

For \( q_k \), there are
\[ \sum_{k=0}^{O-1} q_k = 1. \]  \hspace{1cm} (17)

\( q_k \) is the probability of each gray value, \( t_k \) is the number of pixels with gray value \( k \), and \( T \) is the total number of pixels.

It divides a point in a grayscale image into two regions \( W_0 \) and \( W_1 \) with a segmentation threshold \( A \). \( W_0 \) consists of points with gray values in \([0, A-1]\), and \( W_1 \) consists of points with gray values in \([A, 0-1]\); then, the probabilities of regions \( W_0 \) and \( W_1 \) are
\[ P_0 = \sum_{k=0}^{A-1} q_k, \]  \hspace{1cm} (18)
\[ P_1 = \sum_{k=0}^{O-1} q_k = 1 - P_0. \]  \hspace{1cm} (19)

The total variance of regions \( W_0 \) and \( W_1 \) is
\[ \sigma^2_C = P_0 (\phi_0 - \phi)^2 + P_1 (\phi_1 - \phi)^2 = P_0 P_1 (\phi_0 - \phi_1)^2, \]  \hspace{1cm} (20)
where \( \phi \) is the average gray level of the entire image and \( \phi_0 \) and \( \phi_1 \) are the average gray levels of the regions \( W_0 \) and \( W_1 \), respectively.
The record of the Guangdong team in its heyday is shown in Table 2.

It can be seen from Table 2 that in these five seasons, the professionalization process of CBA has continued to advance, and the league competition period and the number of games have continued to increase. In this case, the number of negative games of the Guangdong team in each season is basically controlled within 10 games, and the average winning rate is as high as 86.03%.

The number of teams participating in the CBA has fluctuated over the course of the league's 22-year reform and development. According to statistical analysis, 34 teams have competed in the CBA league, with 14 withdrawing from the competition. It has grown from 12 teams in the 1995-1996 season to 20 teams today. Thanks to the continuous replacement of new and old teams, the number of foreign players in the first season increased from 1 foreign aid to 42 foreign aids in the 2016-2017 season. The number of foreign aid has continued to grow, and the total number has continued to rise, with a total of 641 person-times. Although the number of certain seasons has decreased compared to the previous season, the total number of foreign players has consistently shown an increasing trend.

As of the 2016-2017 season, a total of 34 teams have participated in the CBA, and there are currently 20 teams. It assigns different points to the different rankings of the top 8 teams in the 22 seasons of the CBA league and then calculates the total points of the top 8 teams in the 22 seasons and ranks them. Table 3 shows the results of Beijing’s domination of the league.

As can be seen from Table 3, the Beijing team dominated the CBA league in the 2011-2015 season. In these 4 seasons, Beijing has won 2 championships and 1 runner-up, among which it won 2 consecutive championships in the 2013-2015 season. With the continuous advancement of the CBA professionalization process, the league competition period and the number of games continue to increase. Under
the circumstance that the strength of each team has been greatly enhanced, the number of regular-season losses in Beijing in the past four seasons has been controlled at 11 games. The number of losses in the playoffs remained at about 3 games, and the season average winning rate was as high as 68%.

The number of championships won by different teams during the Chinese Men’s Basketball Professional League is

| Season       | League places | Regular season | Playoffs          | Season winning percentage |
|--------------|---------------|----------------|-------------------|---------------------------|
| 2008-2009 season | First place   | 45 wins 5 losses | 10 wins 1 loss     | 90.16%                    |
| 2009-2010 season | First place   | 30 wins 2 losses | 10 wins 2 losses   | 90.91%                    |
| 2010-2011 season | First place   | 25 wins 7 losses | 10 wins 2 losses   | 79.55%                    |
| 2011-2012 season | Second place  | 27 wins 5 losses | 7 wins 4 losses    | 79.07%                    |
| 2012-2013 season | First place   | 28 wins 4 losses | 10 wins 0 losses   | 90.48%                    |

Figure 7: Changes in the number of teams participating in the CBA league and the total number of foreign aiders over the years.
shown in Figure 8(a). Figure 8(b) shows the number of times the teams from the four major economic divisions entered the top 8 during the professional league.

It can be seen from Figure 8(a) that during the 12 seasons of the Chinese Men’s Basketball Professional League, the number of teams that have won the CBA championship has gradually increased. Among them, the Guangdong team has won 6 championships, accounting for 50% of the total; the Beijing team has won 3 championships, accounting for 25% of the total; Bayi team won 1 championship, accounting...
for 8%; Sichuan team won 1 championship, accounting for 8%; Xinjiang team won 1 championship, accounting for 8%.

According to the statistical results in Figure 8(b), it can be seen that among the top 8 teams in the 12 seasons of the professional league stage, the eastern region has 70 teams, accounting for 73%, and still has a clear advantage. The teams from the northeast region have 11 times, accounting for 11.5% of the total times; the western teams have 13 times, accounting for 14% of the total times; the teams from the central region have 2 times, accounting for 1.5% of the total times. At this stage, the performance level of the teams in the western region has gradually improved, and the proportion of the top 8 teams has gradually increased. Its representative teams are the Sichuan team and the Xinjiang team, which won the championship in the 2015-2016 and 2016-2017 seasons, respectively. They shattered the pattern of East Coast teams that dominated the league. Therefore, it can be seen that the competition pattern during the professional league still shows a pattern of strength in the east and weakness in the west, but the western region has shown a rising momentum.

Marbury is the first foreign aid in CBA history. As a former NBA All-Star guard, although he continues to grow older, his training is particularly hard. His confrontation ability and breakthrough ability are still excellent, and his passing and organizational skills are still outstanding. The Beijing Shougang team is often saved by his “big heart” three-pointer, and he is the biggest contributor to the three-time Beijing Men’s Basketball Championship. The 2011-2015 season Marbury’s average data in the Beijing team is shown in Table 4.

| Season          | Number of appearances | Number of debuts | Time (min) | Score | Assist | Steals | Rucks |
|-----------------|-----------------------|------------------|------------|-------|--------|--------|-------|
| 2011-2012 season| 45                    | 44               | 33.7       | 27    | 6.3    | 2.4    | 5.4   |
| 2012-2013 season| 36                    | 36               | 35.5       | 28.3  | 5.8    | 2.2    | 4.4   |
| 2013-2014 season| 27                    | 26               | 32.8       | 21.8  | 4.7    | 1.8    | 4.7   |
| 2014-2015 season| 51                    | 49               | 33.1       | 18.4  | 5.9    | 1.4    | 3.5   |

Marbury’s contribution during the three-time Beijing Men’s Basketball Championship was indisputable. The 2011-2015 season Marbury’s average data in the Beijing team is shown in Table 5.

From Tables 4 and 5, we can see that the Beijing team has won the championship in three seasons, and Marbury and Morris are the most important contributors to Beijing’s championship. The two of them averaged over 50 points per game, more than half of the Beijing team’s total. Marbury can not only average high points per game but also assist other players on the team, averaging 5.6 assists per game in 3 seasons. In addition, Morris averaged 9.6 rebounds per game, making a great contribution to the team’s defensive end. In general, the two major foreign aids of the Beijing team have played a huge role in the success of the Beijing team. Relying on the excellent performance of foreign aid Marbury and the outstanding contribution of Morris, coupled with the rise of the team’s overall offensive and defensive strength, it was unique in the CBA league and became the overlord of the CBA league at that time.

The technical statistics of the six star players (Yi Jianlian, Jeremy Lin, Guo Ailun, Zhao Jiwei, Wang Zhelin, and Zhou Peng) in the 2019-2020 season are shown in Figure 9.

It can be seen from Figure 9 that Yi Jianlian averaged 19.5 points and 10.3 rebounds per game in the 2019-2020 season. Overall, the six star players have certain advantages in some individual aspects. The data comparison of the six teams in the 2020-2021 season is shown in Figure 10.

As shown in Figure 10, the overall level of the Guangdong team in the 2020-2021 season is slightly higher than that of the other five teams.

5. Discussion

This paper transforms the operation mechanism of the league, introduces foreign advanced data collection and analysis technology, and conducts specific research combined
with the actual situation of CBA development. In-depth investigations should be conducted on various data collection and analysis techniques used by active NBA teams, local leagues, and more. By learning rich management experience and advanced technical means, it has developed a data collection and analysis plan that is in line with the development of the CBA league.

It is necessary to focus on improving the management system of the CBA database. Data information is the symbol of professional leagues, the embodiment of the fair and open characteristics of basketball events, and the basis for ensuring the professional development of CBA. Through the construction of the network database, it not only provides fans and media with exciting events but also records the development process of teams and players, providing valuable reference materials for related in-depth research.

The generation of big data analysis is aimed at IT management; enterprises can combine real-time data flow analysis and historical relevant data and then big data analysis and discover the models they need. In turn, it helps predict and prevent future outages and performance issues. Further, they can use big data to understand usage patterns and geographic trends, which in turn can deepen big data’s insights into important users. They can also track and record network behavior, and big data can easily identify business impacts. It accelerates profit growth with a deep understanding of service utilization while growing its catalog of IT services by collecting data across multiple systems.
6. Conclusion

The CBA has gradually developed a statistical system for competition data that is critical to the league’s success. In the sports field, data collection and analysis methods are constantly updated, and CBA needs to continue to invest in data collection and analysis technology development. Improving the overall business level of CBA-related data

![Comparison of the six teams' statistics for the 2020-2021 season.](image-url)
The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest
The authors do not have any possible conflicts of interest.

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