A study of the application of operations research in the valuation of players in IPL

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ABSTRACT

The main objective of this whole research is to find out about the ways in which Operations Research could be used in valuing players which in this case are the IPL players. We found out that it is not compulsory that the method used in valuing the players should be numeric. It could be the case that a theory has been used and the players are valued according to that theory. The methods used in order to value the players are a performance-based index, hedonic pricing, ordinary least squares regression technique, and AHP-ANN model. In the performance-based index, the performance of a cricketer is quantified into one single index and present values of the cricketers are determined using the binomial option pricing model. In hedonic pricing, the price of a player is calculated based on internal and external factors. Some of them are Experience, Batting, and Spectator Appeal etc. In ordinary least squares regression technique, the value of a player is calculated by measuring the values of the variables which include experience, performance etc. In AHP-ANN model, AHP is used to measure the weights of the attributes which are responsible for player price measurement and then ANN is used to forecast the player price with the weights calculated by AHP.

Keywords— *IPL, Operations Research, Cricket, Player Valuation, Performance-Based Index, Hedonic Pricing, Ordinary Least square Regression, AHP-ANN Model*

1. INTRODUCTION

The Indian Premier League was launched in April 2008 by the Board of Control for Cricket in India (BCCI). It is based on a variety of different sports like basketball (National Basketball Association, USA) and football (English Premier League). IPL has taken Indian cricket to another level. Lots of money is being invested in this event by businessmen, celebrities and big companies. The aim of this event is firstly, to promote twenty20 cricket, introduced by the English Cricket Board, a version of the game which is shorter and can take less than three hours. Secondly, to create a cricket league, consisting of competitive players and teams, which is successful. Thirdly, to provide another form of family entertainment which is affordable.

There are 8 teams that are part of the tournament, playing, as Twenty20 indicates, twenty overs. Each of the eight teams represents eight different cities of India. The franchise rights of each are auctioned off. Players, Indian and international, can be acquired in a number of ways. One of them is by the way of auction. The auction was conducted in the English style. This is a type of forwarding auction. In this type of auction, bidding starts with a low price, or base price, and keeps on increasing till higher bids are received. This goes on till either no higher bids are received or the auction is closed. The base price is which below which the item cannot be sold. A few rules of the auction are:

- The number of players on the squad should be between 18-25.
- They can have a maximum of 8 overseas players.
- There is a salary cap of the teams is 80 crores.
- There should be 11 players playing at one time in each squad, only 4 of which can be overseas players.
- The franchises can nominate one "icon player". This player earns 15% higher than the highest paid player on the team.

The tournament is played on a "double robin-round" basis. "Robin-round" premise implies that each group plays the other seven groups. "Double robin-round" is the point at which they play each group twice, at home and away. There are two semi-finals, played by the top four teams and then a final match.

Player evaluation is an extremely important part of professional sports, especially when huge sums of money is involved. Every team is constantly attempting to improve their player line-up. This paper explains a few of the methods used to attribute prices to the IPL players. The methods that will be discussed in this paper are Performance Based Index, Hedonic Pricing, Ordinary Least Square Regression Technique, and the AHP-ANN Model.

2. OVERVIEW
The **Indian Premier League** is a professional Twenty-Over cricket league in India held during April and May of every year by teams representing Indian cities and states. The teams consist of players of teams from all countries. A team can acquire players through the player auction, by trading players during the trading windows, and getting replacements for players which are unavailable. Players sign up for the bid and also set their base price, and are acquired by the franchise that bids the highest for them. The most recent edition of the Indian Premier League, a 48-day annual cricket tournament that presents the most brilliant players from across the world, has some massive numbers to enjoy.

IPL has very high broadcasting value with a contract that began with a figure of US$1.026 billion that is now valued at an astonishing US$13 billion, the most costly broadcast rights deal in the cricket history. The IPL became a major television property within India making Sony MAX the most-viewed television channel in the country during the tournament and making its annual advertising revenue surpass ₹1,200 crores. It also sold its digital rights to Facebook helping them earn a huge US$600 million. In 2018, the opening match saw television viewership increase 37 percent over the prior year, advertising costs have almost doubled and some $94 million was spent by the 8 participating teams to buy 168 players from the auction, compared with just $14 million for 66 players in 2017, industry data shows.

The tipping point for the IPL came in September last year when Star India bought the five-year global media rights for an unprecedented $2.55 billion, making the IPL one of the richest sports properties in the world. Valuations experts had evaluated the IPL brand at $5.3 billion in 2017, a 26 percent increase from $4.2 billion in 2016.

IPL has a huge economic impact since according to the BCCI, the 2015 IPL season contributed 11.5 billion Indian rupees to the GDP of the Indian economy and that figure has been increased from the past years.

At least 150 companies are associated with this league. For the 2018 IPL season, India's national team captain Virat Kohli is getting paid US$2.5 million, while former Indian captain MS Dhoni gets US$2.2 million. Even the under-19 players have been auctioned for between $450,000 and $600,000 for one season. The head coaches make between $500,000 and $1 million per season. There is no doubt that everyone associated with this league is making some profit.

3. LITERATURE REVIEW
There are several ways of analyzing a player's performance and putting a value to it. This paper talks about four of them, Performance-Based Index, Hedonic Pricing, Ordinary Least Square Regression Technique, and AHP-ANN Model.

In the Performance-Based Index, the distributional example of the present estimations of cricketers is recognized and cricketers are classified in light of the level of present qualities. Also, the distributional example of the bid price of cricketers is distinguished and the cricketers are characterized on the level of their bid price. The cross arrangement of the classified bid prices and grouped present values can be utilized to distinguish the cricketers who could legitimize their salaries (Saikia, Bhattacharjee & Bhattacharjee, 2013).

Hedonic Pricing Analysis is based on the theory that a good/service can be treated as an accumulation of attributes that differentiates it from other goods/services. The hedonic price equation, in this context, is a locus of equilibrium final bid prices and player attributes, where buyers (team owners) and sellers (cricket players) participate in an auction (Rastogi and Deodhar, 2009).

4. OBJECTIVES
The objectives of the research paper are as follows:
- To analyze the various methods used to find out the valuation of the players in IPL to determine which is the most useful and most accurate method
- To help the team owners decide which players they want on their team and which players they want to drop
- To help the players realize their valuation so they know how much they should be getting paid
- To identify the players who can justify their salary by their performance
- To pick out the players who have been overvalued and to what extent
- To give an objective valuation to the cricketers based on their performance on and off the field
- To help understand that non-cricketing aspects are as important as the cricketing aspects while evaluating a player
- To select important attributes to measure the optimal price and compute the weights to quantify the ideal cost of a player

5. METHODOLOGY
5.1 Performance-Based Index
In this methodology, a measure is developed to quantify the performance of a sportsman into one single index called the Performance-Based Index. In this case for the Indian Premier League, a cricketer's bowling, batting, and wicketkeeping skills are quantified into one single index. Based on this index from the previous seasons and the binomial option pricing, the neutral present values of the cricketers are determined. The Binomial Option Pricing model is a method of valuation of options which was developed in 1979. It assumes a perfectly efficient market. Based on this assumption it can give the mathematical valuation of options at each point in the specified time frame. The approach taken by this model is a risk-neutral approach to valuation.

In this methodology, each of the skills of the players is assessed individually and then we arrive at a single individual index. The batting performance of a player depends on a number of things, the most important being batting average, and the batting strike rate. Batting average is one of the most important. It is the total number of runs scored by a batsman divided by the number of innings in which he was dismissed. It is the number of runs scored by the batsman per 100 balls. The two main bowling statistics are the bowling average and the bowling economy rate. Wicket keeping data does not apply to all the players as only a few of them are wicketkeepers. The fielding skills of the players are not taken into account as there is no way of measuring their fielding skills.

This model can be applicable to other sports as well as football, rugby, baseball and all other sports that work in the same franchisee-based system as the Indian Premier League. This model helps the franchises decided which player should be bought and which should be dropped. It also helps the players know their market valuation so that they have an estimate of how much they should be paid so they are not underpaid.

5.2 Hedonic Pricing
In the hedonic pricing model, the price and evaluation of a player are calculated based on internal and external factors. From the players' point of view, internal factors are their on-field performance factors and external factors amount to their off-field performance factors and values.

Internal factors are those factors which relate to the player's performance on the field. Some of them are:
(i) **Experience–** For IPL, players with more experience in T20 internationals are given more points than ODI experience followed by Test Matches as players in T20 are more efficient compared to ODI and Test Matches because T20 has very limited overs.
(ii) **Batting–** Players with more runs, higher strike rates and a number of boundaries hit earn more points than others.
(iii) **Bowling–** Players with better economy rate (Economy rate is the average number of runs conceded for each over bowled), and more wickets were taken are worth more than other bowlers.
(iv) **Fielding–** Fielding aspects can be mapped with age the age of the player and the catches taken by the player. If two players have the same number of catches then the player who is lower in age will be ranked higher out of the two players. Alternatively, two players having the same age, the criteria would then solely depend upon the number of catches and the player with a higher number will be ranked higher out of the two players.

External factors are mainly those which suggests the off-field popularity of the player. These include:
(i) **Spectator Appeal–** Spectators like those players who score a lot of boundaries during the match, dive around on the field and take spectacular catches.
(ii) **Brand Value–** The player's brand value helps the team in advertisements and promotion. The team at times prefers to take big players in its team just to create the higher brand value of the franchise.

Value = f_1 (internal) + f_2 (external), f_1 (internal) = g_1 (experience, batting, bowling, fielding), f_2 (external) = g_2 (brand value, spectators appeal) and each sub-category earns some points multiplied by base price of the sub-category.

From this method, if we compare the pricing of Mahender Singh Dhoni and Ambati Rayudu, then the price of Mahender Singh Dhoni is justified. Mahender Singh Dhoni has more experience in every format, has a higher strike rate and hit more boundaries. Moreover, he has higher spectator appeal than most of the players and has a brand value like no other player. This makes him an 'icon player'. He has a higher value for any team than Ambati Rayudu. Being an icon player, he will be paid 15% higher than the second highest paid player in the team. Thus, valuation of all big players like Virat Kohli, Ben Stokes, and Chris Gayle etc. can be justified using this valuation model.

(iii) **Icon Player-** Every team has a designated icon player who is paid an amount fifteen percent higher than the highest paid player in that team. The icon players belong to the places that the team is representing. The principal behind icon players is that an iconic player from the vicinity of the home city would be able to generate keen interest in the team and for the tournament.

5.3 Ordinary Least Squares Regression Technique

Value = f (experience, performance, characteristics) + error

The dependent variables used in this Ordinary Least Square Regression technique, cover a variety of performance factors (such as batting and bowling averages) in different forms of cricket like T20 and ODI, experience in different forms of cricket, and characteristics of players (such as age and nationality).

Experience- The most important experience was in international Twenty20 matches, where valuations were higher by about $12,000 per match. However, experience in ODIs was also valuable, valued at $820 per match.

Strike rates- Both indicate the speed at which the game progresses which is crucial in Twenty20 cricket. Each 10-point increase in batting strike rates results in an $11,000 increase in valuations. Each 10-point reduction in bowling strike rates (i.e. fewer balls required to take a wicket) increases valuations by $16,000.

All-rounders- The top 10 ODI all-rounders, as measured by the ICC ratings, earned US$194,000 more than would otherwise have been expected on their batting and bowling performances alone.

Nationality- The restriction to four overseas players means that each team needs many Indian players. Indian players are also likely to be more marketable in India than non-Indian players. The premium for younger Indian players was $419,000, while the premium for older Indian players was still a healthy $240,000.

Icon Players- Unsurprisingly, the five icons – Sachin Tendulkar, Sourav Ganguly, Rahul Dravid, Virender Sehwag, and Yuvraj Singh - earned $354,000 more than would have been expected from their ability and experience alone. Their salaries are derived from the criterion that they are 15% higher than the next highest salary on the side.

AHP-ANN Model
The AHP-ANN Model in IPL is used to estimate the price of a player which depends upon various criteria and then the AHP process is used to measure the weights of the criteria which are responsible for the player price estimation and then ANN is used to find the cost of each player with weights known by AHP.

AHP
Thomas salty (1980) introduced the Analytical Hierarchy Process (AHP) which is a powerful tool for complex decision making and may help to set priorities and make the most optimal decision. It involves organizing several choice criteria into a hierarchy, after understanding the relevance of the criteria then giving them an overall rank for each criterion. AHP helps to find both the subjective and objective aspects of a decision which

6. FEATURES OF PLAYER PRICE ESTIMATION
6.1 Player's Performance Appraisal
• Number of a man of the match won by a player
• The capability of winning a match

- Past performance of the player
- Performance appraisal of each player

6.2 Player's Experience Contribution
- Age of the players
- Popularity
- Fielding Ability
- Added role of the player

6.3 Player's recent form
- International tournaments played
- Indian or overseas player
- Recent T20 International team member.
- Recent One Day International member.
- Recent ICC T20I rating.
- Recent ICC ODI rating.

Step 1: Perform Pair-wise Comparison according to Saaty's nine-point preference scale.

Table 1: Saaty's Nine-Point Preference Scale

Scale	Compare factor of I and j
1	Equally Important
3	Weakly Important
5	Strongly Important
7	Very Strongly Important
9	Extremely Important
2,4,6,8	Intermediate value between adjacent scales

Let a represents n x n pair-wise comparison matrix:

$$A = \begin{bmatrix} 1 & a_{12} & ... & a_{1n} \\ a_{21} & 1 & ... & a_{2n} \\ ... & ... & ... & ... \\ a_{n1} & a_{n2} & ... & 1 \end{bmatrix}$$

Step 2: Normalize the raw score by Arithmetic Mean

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \quad j = 1, 2, ..., n$$

Step 3: Perform a Consistency check.

Step 3a: Let C denotes an n-dimensional column vector describing the sum of the weighted values for the importance degrees of the attributes, then

$$C = [C_i]_{nx\,I} = AW^T, i = 1,2, ..., n$$

Step 3b: To avoid inconsistency in the pair-wise comparison matrix, Saaty suggested the use of the maximum Eigen value λ_{max} to calculate the effectiveness of judgment. The maximum Eigen value λ_{max} is as follows:

$$\lambda_{max} = \frac{\sum_{i=1}^{n} c.v_i}{n}, \quad i = 1,2, ..., n$$

Step 3c: With λ_{max} value, a consistency index (CI) can then be estimated by:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Step 3d: Consistency ratio (CR) can be used as a guide to check the consistency

$$CR = \frac{CI}{RI}$$

Where RI denotes the average random index with the value obtained by different orders of the pair-wise comparison matrices.

7. ANN
Artificial Neural Networks or connectionist systems are computing systems that draw inspiration from the neural networks found in the animal brain. Such systems have the capability to understand and perform tasks using examples, without normally being programmed with such task-specific rules. For example, such systems might learn to identify images that have cars in them by analyzing sample pictures that have manually been labeled as a car or no car and using said images they further identify cars in other images. This is done even though there is no prior knowledge of cars, e.g. a car has wheels, windows, steering wheel etc. Rather they automatically distinguish identifying traits using the material they analyse.

ANN loosely models the human brain where a collection of units or nodes is called artificial neurons, similar to that of the biological brain. Much like the brain, each of these connections can send signals from one artificial neuron to the other ones connected to it. Once a neuron receives the signal and process it and further send it out to connected neurons.

In most cases where Artificial Neural Networks are used, the signal at a connection between is made up of a real number and the output produced by each artificial neuron is computed using a non-linear function of the inputs. The connection between two neurons is referred to as 'edges'. The weight of the Neuron and the edges adjusts as the learning proceeds. The weight impacts the strength of a signal at a given connection. At times, artificial neurons may have a threshold such that a signal can only pass in case the signal crosses the given threshold. Artificial neurons are segregated into many layers. Various layers perform various transformations on their inputs. Signals travel between the first and last layer possible after going through all the layers multiple times.

The ANN was designed with a goal to solve problems in a way similar to the human mind. Over time, this has changed as the attention had shifted to performing specific tasks, deviating from biology. ANN has been used for a wide array of tasks, comprising of machine translation, social network filtering, playing board, and video games and even medical diagnosis.

The artificial neural network is used to verify the results of AHP and to predict the alternatives' ranking. At first, AHP is utilized to gauge the weights of the properties which are in charge of player value estimation and afterward ANN is utilized to conjecture the player cost with the weights figured by AHP.

8. CONCLUSION
This paper has developed a model for estimating the value of an IPL player by using the combination AHP-ANN, Hedonic Pricing, Ordinary Least Squares Regression Technique, and Performance-based Index. These three models are used to quantify the performances of the cricketers in order to find their accurate valuation. The Performance-based Index combines bowling, batting, and wicket-keeping skills in order to form one index and hence quantify their performances to find out how much they should be paid. The Hedonic pricing model takes into account the internal and external factors in order to come up with the valuation. The Least Square Regression model accounts for the experience, performance, and characteristics of the players to evaluate the players. The AHP-ANN model helps us to handle the complexity and selecting the attributes for player price calculation.

Our results show that some players got much more price than they deserved and some players did not get the right price in

accordance to their optimal potential. The icon players like Sachin Tendulkar, Rahul Dravid, Yuvraj Singh, and Virender Sehwag got a sum 15% more than what would have been expected. This paper helps the bidder to put in a bid of the players with more proficiency and excellence, investing the optimal amount fit for the player. Restraint of excess bidding is attained through the method described. An optimistic and bright area of future research would be the assemblage of a victorious cricket team with players selected from optimally found criteria values and minimum budget by applying this approach.

9. LIMITATIONS
The paper used the secondary research method with a review of documents and reliable websites available in the public domain. Company financial documents of franchises and advertising agencies were not available for research. The software required to calculate the valuations of players according to the above-mentioned methods was not easily available and complex and therefore, we decided to keep this as a theory paper.

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